CRESST REPORT 798

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IMPROVING THE WAY WE DESIGN GAMES FOR LEARNING BY EXAMINING HOW POPULAR VIDEO GAMES TEACH

JULY, 2011

The National Center for Research on Evaluation, Standards, and Student Testing

Graduate School of Education & Information Sciences
UCLA | University of California, Los Angeles

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Abstract

One of the reasons why commercial video games are popular is that they effectively teach players how to play the game—in many cases as the player plays the game itself. This paper focuses on how to effectively integrate teaching "how to play a game" with teaching an "instructional domain" within a game for learning. By analyzing more than 30 popular commercial games, the authors (a) map instructional methods and strategies as well as related constructs which illustrate how games teach game play mechanics, game controls, and interface elements, and (b) prescribe ways to map those methods and strategies to methods and strategies applicable to teaching specific instructional content (e.g., fractions).

Introduction

Research findings strongly support the argument that learning outcomes from games for learning are affected by the instructional methods and strategies employed in the games and not necessarily by the games in and of themselves (e.g., Garris, Ahlers, & Driskell, 2002; Thiagarajan, 1998; Wolfe, 1997). Recently, however, researchers have begun to argue that learning outcomes from games for learning also depend on how well the domain instruction is integrated into the game; that is, how well domain instruction is perceived as part of the game (Becker, 2006; Egenfeldt-Nielsen, 2006; Fisch, 2005). Blending game instruction with domain instruction can reduce *germane load* (which is the cognitive load required by the methods used for presenting new knowledge to a learner) (Ayres, 2006; Renkl & Atkinson, 2003). A reduction in germane load can in turn reduce overall *cognitive load* (which is the amount of mental activity imposed on working memory at an instance in time) (Chalmers, 2003; Sweller & Chandler, 1994).

We contend that one of the reasons certain commercial video games are popular is because they effectively teach players how to play the game. In fact, commercial video games have managed to garner the largest share of an extremely competitive market. If these games were difficult to learn, they would most likely not have achieved such popularity. A recent study by Wainess, Koenig, and Kerr (2011) supports this very argument: The authors found that one set of instructional methods and strategies can be mapped onto the instructional needs of both the game and the learning domain by (a) gaining an understanding of the instructional methods and strategies popular commercial games utilize for teaching various elements of a game, and (b) defining those same game elements in terms that can translate to learning domains.

This paper presents the latter phase of an ongoing research agenda, which focuses on how to effectively integrate teaching “how to play a game” with teaching an “instructional domain” within a game for learning. In the current phase, we (a) map instructional methods and strategies as well as related constructs that illustrate how games teach game play mechanics, game controls, and interface elements, and (b) prescribe ways to map those methods and strategies to methods and strategies applicable to teaching specific instructional content (e.g., fractions).

Figure 1 illustrates the link between instruction and game play as well as the path from learning goal to game genre. The left side of Figure 1 indicates that learning goals determine the types of instructional methods and strategies that are used. *Instructional methods* are external supports for metacognitive processes and *instructional strategies* are approaches to learning. Instructional strategies can benefit from the inclusion of instructional methods. To achieve a seamless integration of game and instructional domain, instructional methods and strategies used for the learning domain should be mapped to how game play (game strategies and game tactics) and game mechanics are taught.

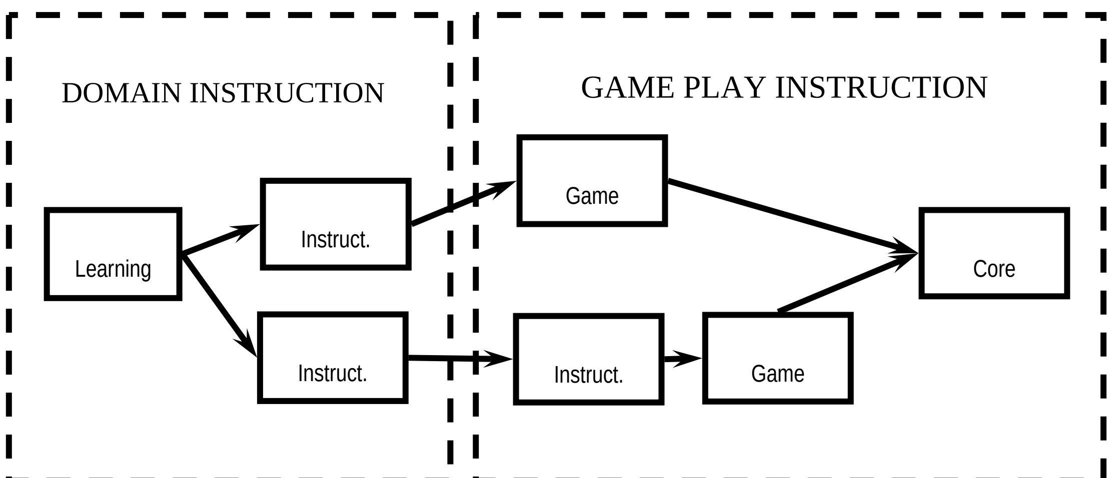

Figure 1. How domain instruction and game play instruction are linked.

The right side of Figure 1 shows how the methods and strategies for teaching the components of games and game play are linked to those for teaching a learning domain (the left side). The game strategies (the instructional strategies utilized for learning a game) are linked to the instructional strategies that are utilized for teaching the learning domain.

Similarly, the instructional methods used for learning a game are linked to the instructional methods utilized for teaching the learning domain. In this way, one set of instructional strategies and methods are used in teaching both the game and the learning domain.

The chain of items starting from the game's instructional methods box and moving to the right indicates that the selected instructional methods should be utilized for teaching all of the game's mechanics. *Game mechanics* are the actions a player can perform, governed by the game rules. *Core mechanics* are one or more game mechanics that comprise the primary means to advance the game state toward the game's goal(s). A *game genre* is a collection of core mechanics. Since game genres, core mechanics, and game mechanics are all representations of game mechanics, all would be taught using the same instructional methods and strategies. Therefore, to achieve seamless integration between learning the game and learning the instructional domain, core mechanics and game mechanics should be taught using the same instructional methods and strategies used for teaching the learning domain, or vice versa. In other words, the learning domain should be taught using the same methods and strategies that are used to teach the game. This report focuses primarily on instructional methods, rather than instructional strategies. The only instructional strategy examined in this report is guided versus unguided learning.

Theoretical Frameworks

Four theoretical frameworks are relevant to examining instruction within games for learning:

1. Cognitive load theory
2. Instructional methods and strategies
3. Game Play Model
4. Player interaction framework

Cognitive Load Theory

Cognitive load theory (Baddeley, 1986; Brunken, Plass, & Leutner, 2003; Kalyuga, Chandler, & Sweller, 1998; Mayer & Moreno, 2003; Mousavi, Low, & Sweller, 1995; Renkl & Atkinson, 2003) is concerned with the development of instructional methods aligned with learners' limited cognitive processing capacity (limited working memory).

Instructional Methods and Strategies

The terms *instructional method* and *instructional strategy* refer to different instructional elements. The following explains and defines the terms. Scaffolding is concerned with reducing cognitive load during learning and problem solving (Allen, 1997; Chalmers, 2003;

Paas, Tuovinen, Tabbers, & Van Gerven, 2003; van Merriënboer, Clark, & de Croock, 2002; van Merriënboer, Kirschner, & Kester, 2003). According to Clark (2003), instructional methods are designed to control cognitive load. Therefore, scaffolding is an instructional method. Clark (2001) also commented that instructional methods are external representations of internal cognitive processes that are necessary for learning but which learners cannot or will not provide for themselves. Therefore, instructional methods support metacognitive processes, such as learning goals (Alessi, 2000; Clark, 2001), planning (Jones, Farquhar, & Surry, 1995), monitoring (Clark, 2001; Alessi, 2000; Clark, 2001; Leemkuil, de Jong, de Hoog, & Christoph, 2003), and selection (Alessi, 2000; Clark, 2001). Thus, we define instructional methods as external supports for metacognitive processes.

In contrast to instructional methods (which are designed to control cognitive load), there are other instructional devices that are not implemented with the purpose of reducing cognitive load (e.g., discovery learning, inquiry-based learning, problem-based learning, case-based reasoning, and anchored instruction). Kirschner, Sweller, and Clark (2006) argued that discovery, problem-based, experiential, and inquiry-based techniques are not effective approaches to learning because of issues related to prior knowledge. This argument implies that those learning approaches do not, in and of themselves, attempt to control for cognitive load. Therefore, we would argue that discovery learning, inquiry-based learning, etc. are *instructional strategies* and not instructional methods.

David Merrill (2000) commented that essential elements of an instructional strategy include the following: goal, knowledge structure, presentation, exploration, practice, and learner guidance. Hence, Merrill positions instructional strategy as a package that contains instructional methods (goals, guidance), instructional modules (presentation, exploration, practice) and a representation of the instructional domain (knowledge structure). In referring to the seven strategies that define constructivist learning, Savery and Duffy (2001) listed collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance, and pluralism. None of those descriptors suggest a goal of controlling cognitive load. Astleitner and Leutner (2000) offer several instructional strategies related to failure—including the need to create a relaxed environment and treating mistakes as opportunities for learning; yet, these do not suggest a primary goal of controlling cognitive load. Rather, they represent an approach to learning or a packaging within which instructional methods can be employed.

In all the aforementioned examples for instructional strategies, an approach to learning (rather than a way of controlling cognitive load) is described. Therefore, we offer the following definition: Instructional strategies are approaches to learning that can benefit from the inclusion of instructional methods.

Game Play Model

The Game Play Model (Figure 2) illustrates the relationships among the components of a game and is linked to game play instruction by the player interaction framework (see Figure 3). Wainess and Koenig (2010) define a game as the rules, goals, affordances, and effects within a game space. A game space is defined as the bounds in which game play occurs. Game play is defined as the actions that occur as part of a game. The following describe the components of the Game Play Model (Figure 2).

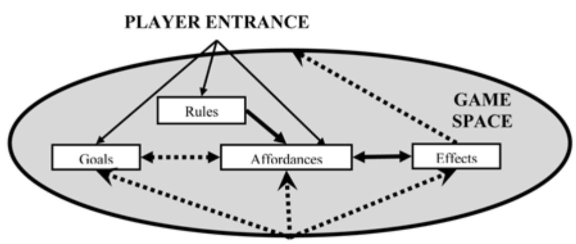

Figure 2. Game Play Model.

Rules: Define what can and cannot be done in a game by a player or computer controlled entity, the conditions under which what can or cannot be done might change, and the way in which players can and cannot interact with the game and with each other.

Goal(s): A game must include one or more goals. That is, a game must have one or more in-game goals (goals during the game), one or more end-game goals (a "game over" state), or some combination of in-game and end-game goals.

Affordance(s): Affordances are what the player is able to do. These are both defined and constrained by the rules of the game and may be modified during game play. In some games (e.g., chess), affordances do not change during the game. In other games (e.g., action video games), the player usually starts with some affordances (e.g., the ability to move) and, over time, acquires more affordances (e.g., weapons, vehicles, the ability to climb).

Game space: Refers to the bounds in which game play occurs. For checkers, the game space is an 8 × 8 grid of squares. For a role-playing video game, it might be a city or an island. For a turn-based strategy game, it might be a continent or the world.

Effect(s): The reactions to or results of a player action; effects can also be the reactions to or results of the game space. Effects are instantiations of the rules of the game and the description of the game space. As instantiations of the rules of the game, effects are what happen in response to a player, based on the rules. In checkers, if a player jumps an opponent's piece, that piece is removed. That removal is an "effect" of a player action.

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 depicts the ways in which information is either presented to the player or how the player can seek out information.

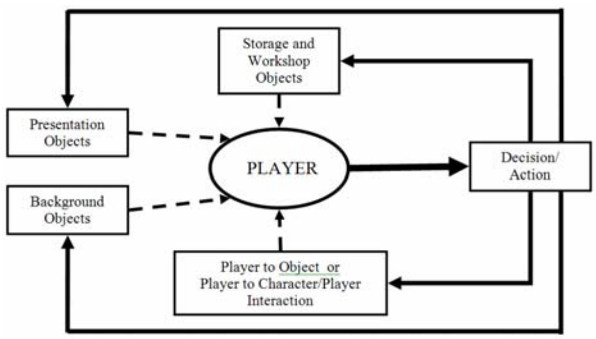

Figure 3. Player Interaction Framework.

Presentation objects: Refer to instruction directly presented to the player.

Background objects: Refer to information or instruction that is covertly integrated into the environment and that requires the player to actively pursue (look for) the information.

Person-to-object interaction and *person-to-character/player interaction:* These interactions are similar. In both cases, the object or character/player (a computer-controlled character or a character representing and controlled by another player) is highlighted (visually emphasized), cueing the player that the object or character/player is important and should be interacted with.

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

Methods and Data Sources

We conducted an exploratory study examining 34 commercial video games—including ten action games, nine first person shooters (FPS) and third person shooters, three sports games, three action/adventure games, three platform games, two racing games, two role playing games (RPG), one adventure game, and one rhythm/dance game. Two coders were given training on a variety of instructional methods and strategies. The Appendix at the end of this report shows the table provided to the coders (which lists the instructional methods and strategies along with definitions and game-related examples for each). As a group, the trainer and the two coders examined the game *Jett Set Radio Future on the Xbox*™, to practice the coding process. The training involved playing a game segment then discussing what was taught and which instructional constructs were utilized in the instruction. The coders examined the game for the following.

1. Game play element taught (based on the components of the Game Play Model, see Figure 2)
    a. Psychomotor skill (introduction of an affordance)
    b. Task (presentation of a goal)
    c. Constraint (introduction of a game rule)
    d. Tool (introduction of an affordance)
    e. State (introduction of an interface element to monitor the player's state)
    f. World space (introduction of an interface element to show or monitor the world space)
2. Mode of interaction (how information was introduced to the player, based on the Player Interaction Framework, see Figure 3)
    a. Presentation object
    b. Person-to-object
    c. Background object
    d. Workshop function
3. Instructional scaffold
    a. Providing goals
    b. Task lists
    c. Advance organizers
    d. Resource lists
    e. Cueing
    f. Feedback (implicit, simple explicit, and elaborated explicit)
    g. Worked examples
4. Amount of guidance
    a. Guided versus unguided learning
5. Instructional segmenting
    a. Part task
    b. Part-whole task

c. Whole task

6. Instructional timing

   a. Pre-training

   b. Just-in-time training

After initial training, the two coders examined one game independently. Comparisons of their codes indicated interrater reliability of 70% or higher, depending on the instructional feature, with reliability for most features exceeding 80%. These percentages were considered sufficient to allow all subsequent games to be examined by only one rater.

Table 1 lists the 34 games that were analyzed, each game's genre, and the number of events (frequency) entered for each game. Each event resulted in the generation of one or more codes; moreover, most events resulted in multiple codes. An event is defined as the teaching of, reminder of (through repetition), or combining (elaboration) of game features, game controls, or game interface elements. For example, for AirForce Delta Storm, the coders entered 18 events. One event might be the introduction of a game control function (e.g., when to click a particular button), which would result in a code for group 1 above (which game play element was taught), group 2 (how the information was presented to the player), group 4 (whether the learning was guided or unguided), group 5 (how it was segmented), and group 6 (when it was taught, in relation to when it was needed). Depending on how it was taught, it might also include a code from group 3 (e.g., if it were introduced via a worked example).

Table 1

The Thirty Four Games Analyzed

Game title	Genre	Frequency
AirForce Delta Storm	Action	18
Battlefield 1942	FPS	15
Britney's Dance Beat	Rhythm/Dance	15
Call of Duty 2	FPS	52
Crash-Tag Team Racing	Racing	40
Genji: Days of the Blade	Action	63
Ghost Recon Advance War Fighter	3rd Person Shooter	92
Halo	FPS	32
Heavenly Sword	Action	40
Hot Shots Golf: Fore	Sports	17
Hot Shots Golf: Out of Bounds	Sports	21

Game title	Genre	Frequency
Indiana Jones	Action/Adventure	34
Katamari Damacy	Action	28
Kingdom Hearts	Action RPG	35
Kung Fu Panda	Action	36
Little Big Planet	Platform	31
Lost Worlds	Action/Adventure	24
Madagascar	Action	50
Medal of Honor: Frontline	FPS	34
Oddworld: Munch's Oddysee	Adventure	50
Open Season	Action/Adventure	42
Over the Hedge	Platform	53
Perfect Dark Zero	FPS	37
Ratatouille	Action	47
Resistance 2	FPS	38
Sega GT 2002	Racing	23
SOCOM: US Navy Seals	3rd Person Shooter	38
Soldier of Fortune	FPS	19
Sonic Heroes	Platform	37
Splinter Cell	Action	63
SpongeBob Square Pants	Action	32
Spyro: The Eternal Night	Action	29
Teenage Mutant Ninja Turtles	Platform	37
The Elder Scrolls III – Morrowind	RPG	32

Analyses and Results

Using descriptive statistics, we examined the relationship between the instructional method or strategy used and the game element taught, the relationship between player interaction modes and instruction method or strategy used, and the relationships among instructional method and strategy. We report on the following relationships between:

1. Game element taught and instructional method or strategy used
2. Type of feedback provided and instructional method or strategy used
3. Amount of guidance provided and instructional method used
4. Player interaction mode and instructional method or strategy used.
5. Type of instructional segmenting and instructional method used.

6. Type of re-exposure and instructional method used.

Based on a common rank segmenting scheme of quartiles, we have chosen 25% as the cut score for an instructional feature (player interaction mode, instructional method, or instructional strategy) to be ranked as sufficient enough to be considered as a useful approach when introducing a game element. In other words, if a feature is used 25% or more of the time, it should be considered as a viable instructional tool.

Game Element Taught and Instructional Method or Strategy Used

We analyzed the frequency of use of the various instructional features to teach each of the six game play elements, which are based on the components of the Game Player Model (Figure 2). Figure 4 shows the results of examining the amount of guidance utilized. All six game element categories were primarily taught using a guided learning strategy. Constraints (rules) were taught a sufficient percentage of the time (31.6%) using unguided learning.

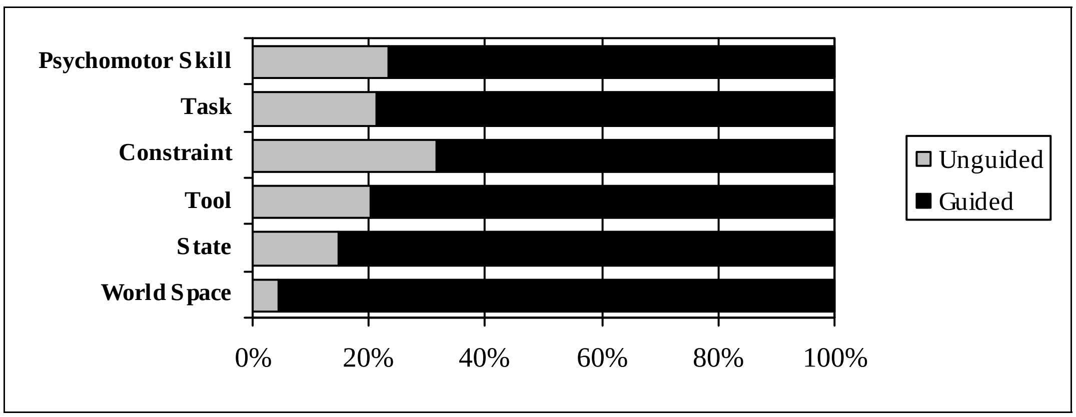

Figure 4. Amount of guidance provided when introducing game elements.

Figure 5 shows that a mixture of implicit training feedback and simple explicit feedback was utilized during introduction of the various game elements. Implicit feedback was the dominant choice for introducing psychomotor skills and constraints (rules), while simple explicit feedback was also used for both game play elements (but not as often). The other four game play elements were introduced with similar amounts of implicit feedback and simple explicit feedback. Elaborated explicit feedback was not sufficiently utilized to teach any of the game play elements.

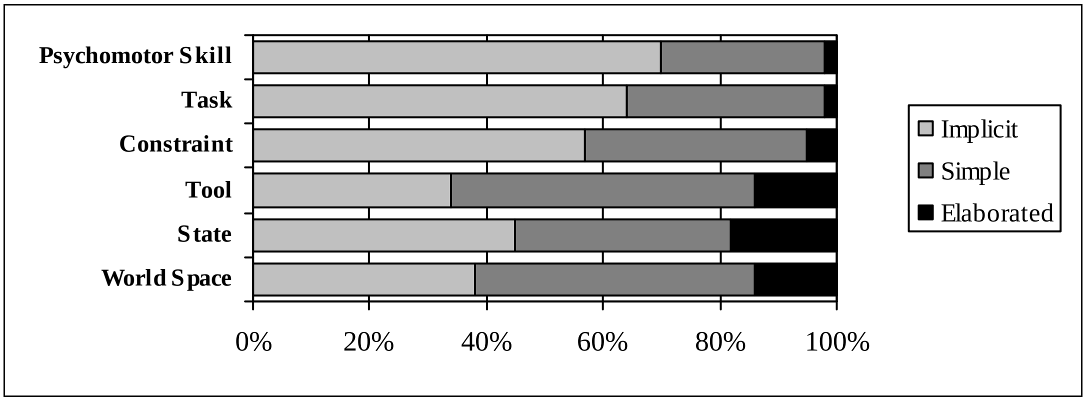

Figure 5. Type of feedback utilized when introducing game elements.

Figure 6 reveals that a mixture of presentation and person-to-object interactions were utilized when introducing game elements. Tools were introduced equally via presentation and person-to-object interactions (42% each). Constraints (rules) and tasks were introduced more via presentation objects than through person-to-object interactions. The remaining game play elements were introduced primarily via presentation objects. It should be noted, however, that person-to-object interactions were nearly utilized a sufficient percentage of time to recommend for introducing psychomotor skills (23.8% of the time).

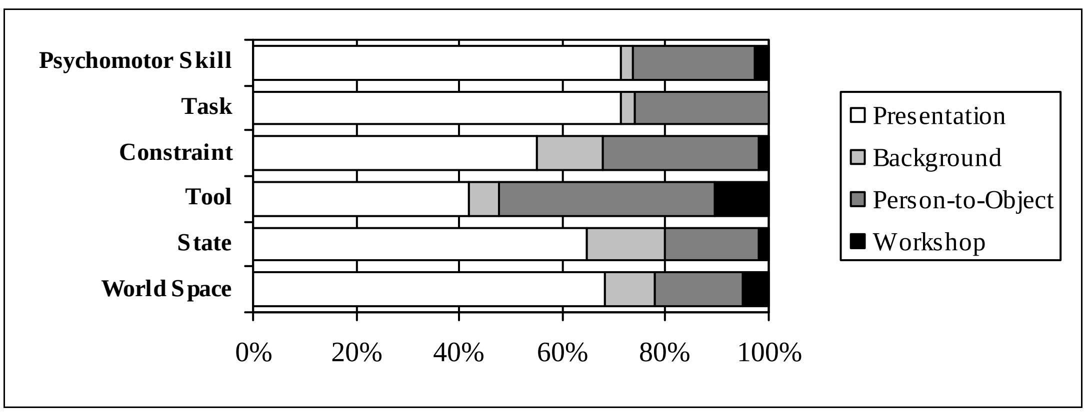

Figure 6. Player interaction mode utilized to introduce game play elements.

Figure 7 shows, for task and state (player state) elements, pre-training was the dominant form of instructional timing—with tasks also being taught a sufficient amount of time (30.8%) via just-in-time training. Psychomotor skills were taught more with just-in-time training (62%) than with pre-training (38%). World space elements were introduced primarily via just-in-time training, while constraints (rules) were introduced with similar amounts of pre-training and just-in-time training (53.8% and 46.2%, respectively).

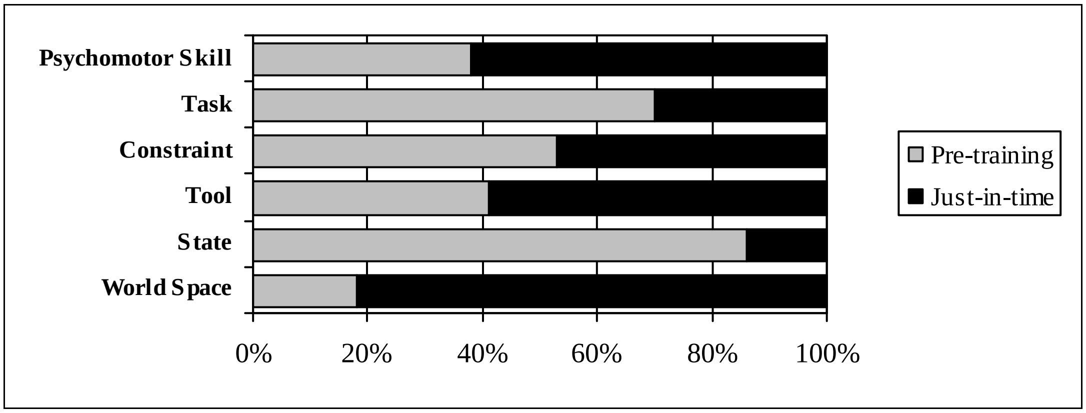

Figure 7. Instructional timing for introducing game play elements.

According to Figure 8, part task training was the dominant form of instructional segmenting for all game elements, while part-whole task training was also used a sufficient amount of time for introducing tasks and tools (27% and 28.3%, respectively). Use of part-whole and whole task training for introducing elements was nearly sufficient to recommend as instructional methods (both were utilized 22% of the time).

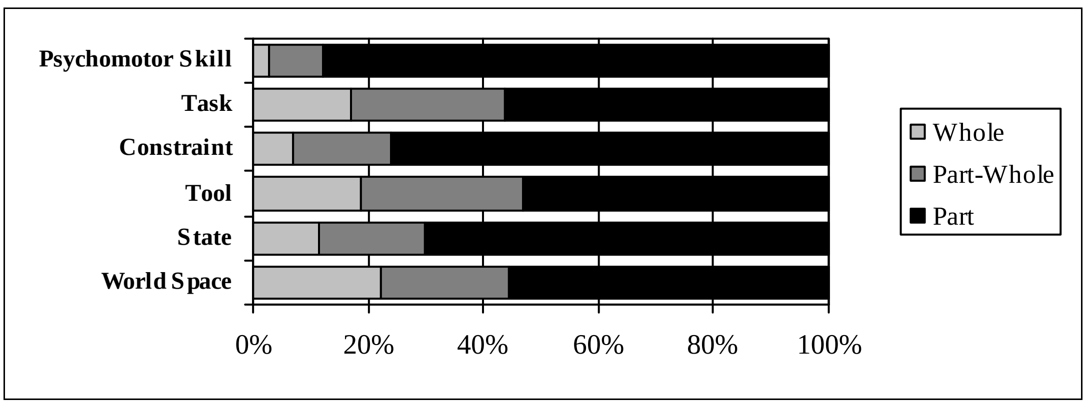

Figure 8. Instructional segmenting utilized for introducing game play elements.

As shown in Figure 9, repeated exposure to world space elements occurred equally via repetition and elaboration: 50% for both. Tools and psychomotor skills were reinforced more through repetition but also sufficiently through elaboration (62.5% versus 37.5% for tools and 58.8% versus 41.2% for psychomotor skills). Tasks were revisited more often through repetition than elaboration (72.7% versus 27.3%). Player state elements were revisited more through elaboration than repetition (58.3% versus 41.7%). Game constraints (rules) were revisited more often with repetition than with elaboration (62.5% versus 37.5%).

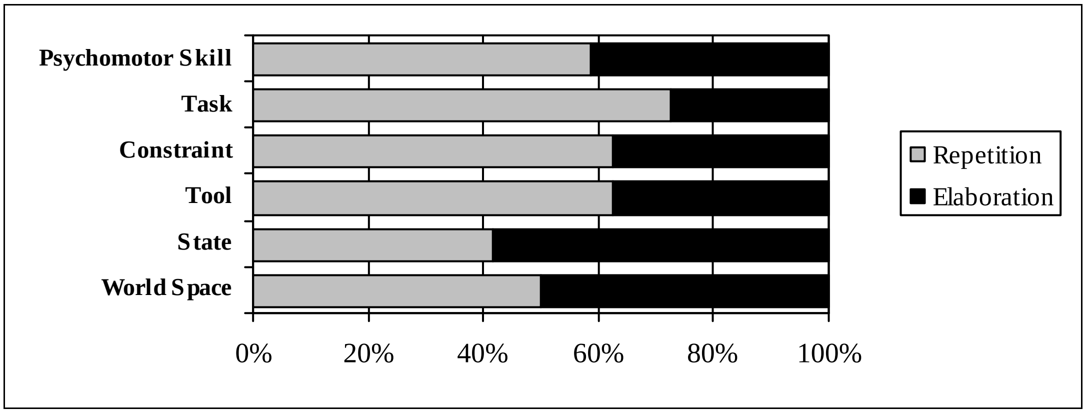

Figure 9. Re-exposure methodology for game play elements.

Figure 10 shows cueing was utilized more often than no-cueing, when teaching all game elements except for psychomotor skills, which was taught primarily with no-cueing. However, when teaching all game play elements, the opposite cueing-related approach was also sufficiently utilized. In other words, while psychomotor skills were predominately taught without cueing, a sufficient amount of instruction of psychomotor skills was also taught with cueing (33.8%). And while the remaining game elements were taught predominantly with cueing, a sufficient amount of instruction on these elements was also taught without cueing (non-cueing scores ranging from 28.4% to 36.2%).

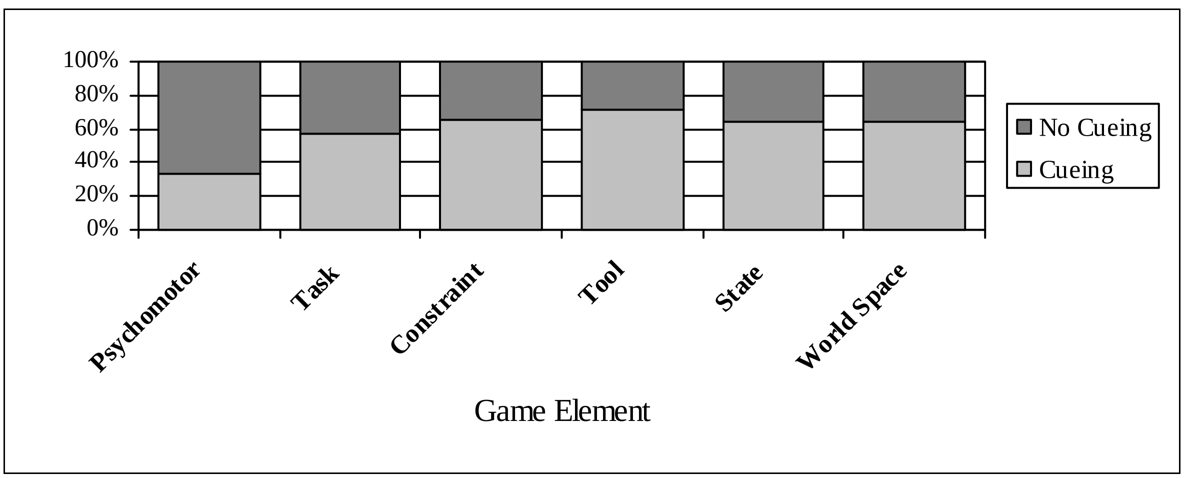

Figure 10. Amount of cueing provided, based on the game element being taught.

Type of Feedback and Instructional Method or Strategy Used

The previous seven graphs depicted the relationship between the six game play elements (which map to the game play component shown in Figure 2) and various instructional methods and strategies, including how the information was presented to the player (see the Player Interaction Framework, Figure 3). The next five graphs focus on the type of feedback utilized (based on the type of instructional method utilized).

Figure 11 illustrates that implicit feedback was the dominant form of feedback, regardless of the amount of guidance given. In addition, simple explicit feedback was utilized a sufficient amount of time, regardless of the amount of guidance given, to be considered as an instructional support. Furthermore, elaborated explicit feedback was rarely used.

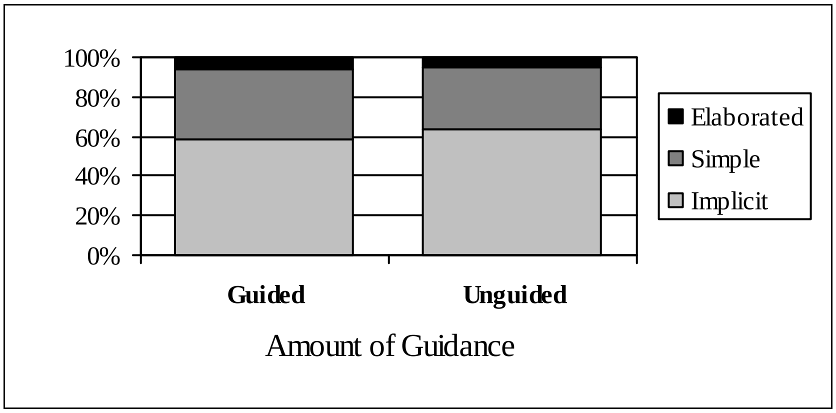

Figure 11. Type of feedback provided, in relation to the amount of guidance given.

As shown in Figure 12, the type of feedback that was used varied based on the type of instructional segmenting used—with all segmenting formats using sufficient amounts of both implicit and simple explicit feedback. Part task training primarily used implicit feedback (67.6%), but also utilized a sufficient amount of simple explicit feedback (29.3%). Part-whole task training used equal amounts of implicit and simple explicit feedback (45.3% and 46.3%, respectively). Whole task training used more simple explicit feedback than implicit feedback. Elaborated explicit feedback was rarely used.

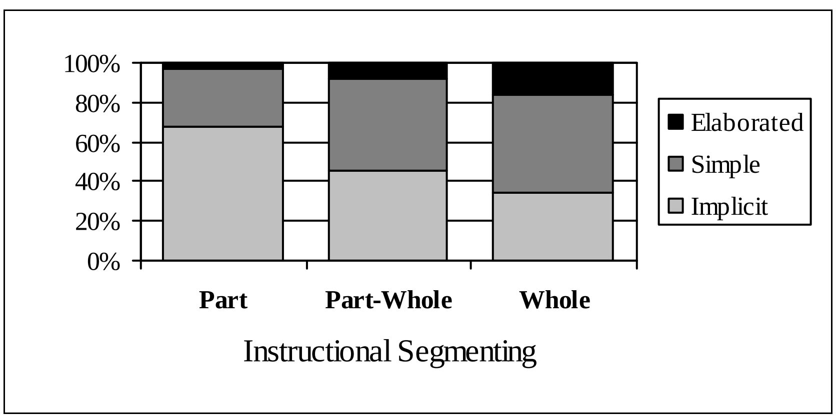

Figure 12. Type of feedback provided, based on the instructional segmenting used.

Figure 13 shows implicit feedback was the dominant form of feedback when utilizing presentation and workshop objects for introducing game elements; yet, simple explicit feedback was also employed a sufficient amount of time when presentation objects were used (30.5% of the time). Implicit feedback and simple explicit feedback were utilized similarly when background objects and player-to-object interactions were used for introducing game elements (43.1% versus 39.2% for background and 43.0% and 49.6% for person-to-object). Almost all feedback when using workshop objects was via implicit feedback (81.3%).

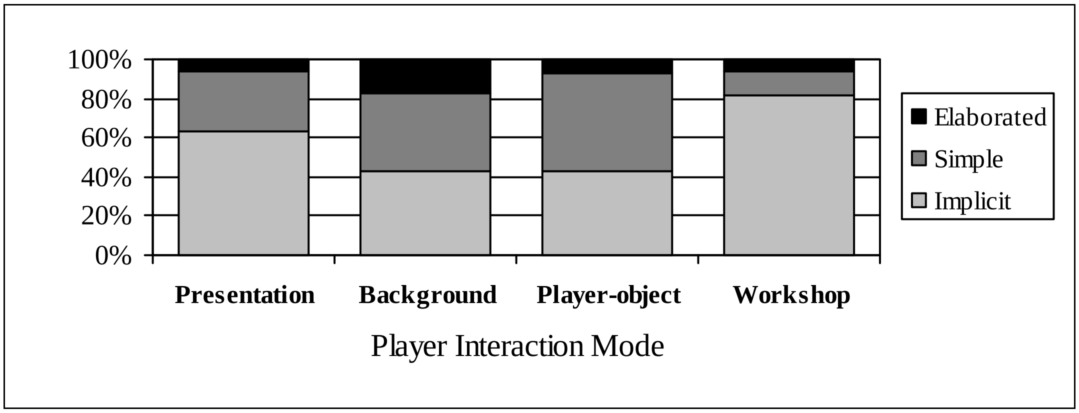

Figure 13. Type of feedback given, based on the player interaction mode utilized.

As can be seen in Figure 14, while implicit feedback was the predominant form of feedback, regardless of the timing of instruction, simple explicit feedback was also used a sufficient amount of time for both forms of instructional timing (26.5% for pre-training and 31.1% for just-in-time training) to be considered as a viable instructional support.

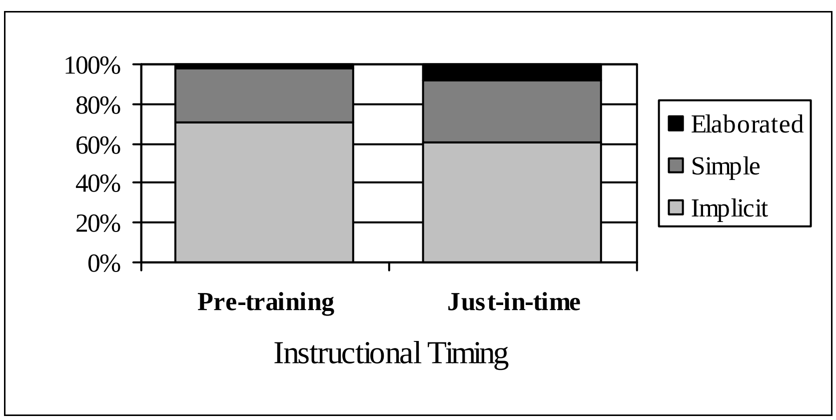

Figure 14. Type of feedback given, based on the timing of instruction.

Figure 15 shows, for both repetition and elaboration, implicit feedback was the dominant form of feedback; however, simple explicit feedback was also sufficiently utilized during repetition and elaboration (29.5% and 31.8%, respectively).

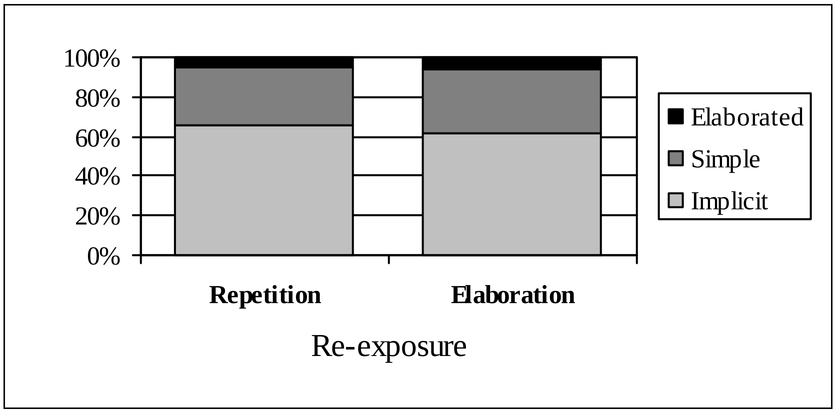

Figure 15. Type of feedback given in relation to re-exposure methodology utilized.

Amount of Guidance Provided and Instructional Method Used

Next, we examined the relationship between amount of guidance, which we defined as a binary variable (no guidance versus guidance), and the type of instructional method utilized. Figure 16 shows guided learning was the predominant form of guidance for all methods by which information was presented to the player, except for workshop objects, which utilized equal amounts of guided and unguided learning (50% for each). Unguided learning was also utilized a sufficient amount of time with person-to-object interactions (31.3%) and neared sufficiency to be a recommended instructional strategy for use with background objects (23.4%).

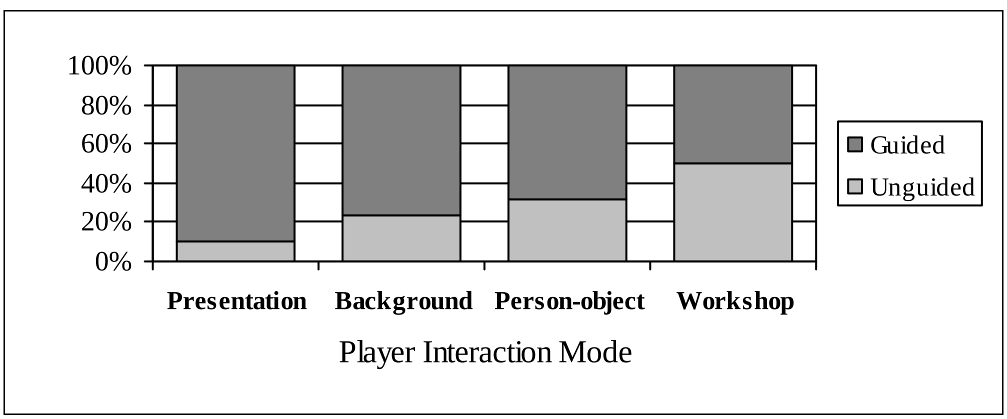

Figure 16. Amount of guidance provided, based on the player interaction mode utilized.

Figure 17 reveals that guided learning was the dominant instructional strategy, regardless of instructional timing; in fact, there was 97.8% usage with pre-training and 97.6% usage with just-in-time training.

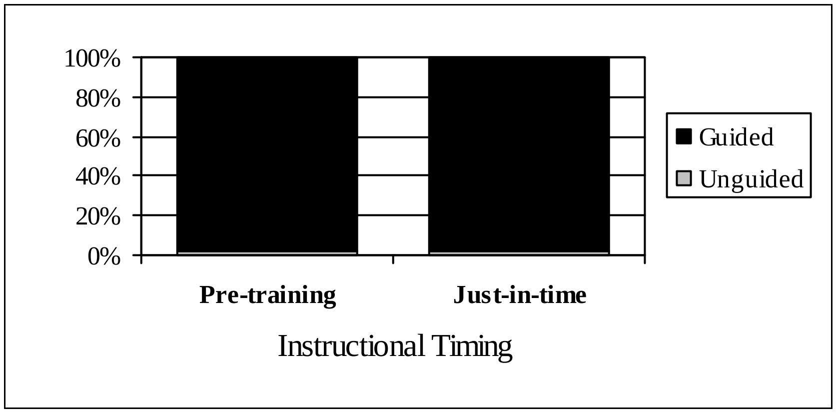

Figure 17. Amount of guidance provided, based on the timing of instruction.

As indicated by Figure 18, guided learning was the dominant form of guidance strategy, regardless of instructional segmenting. However, unguided learning neared sufficient usage (24.3%) when using part-whole training to be considered an instructional strategy.

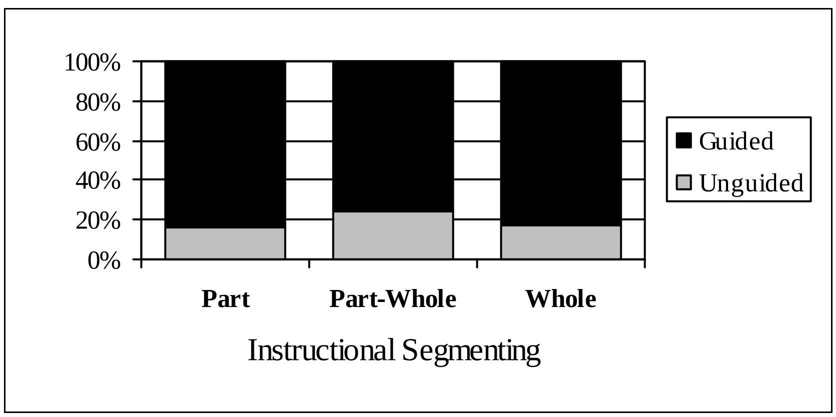

Figure 18. Amount of guidance given, based on the segmenting of instruction.

Figure 19 shows repetition utilized somewhat similar amounts of guided and unguided learning (56.2% versus 43.8%, respectively). By contrast, guided learning was the dominant form of guidance (71.3%) whenever elaboration was utilized; however, unguided learning was used a sufficient amount of time (28.7%) when elaboration was utilized to be considered a viable instructional strategy.

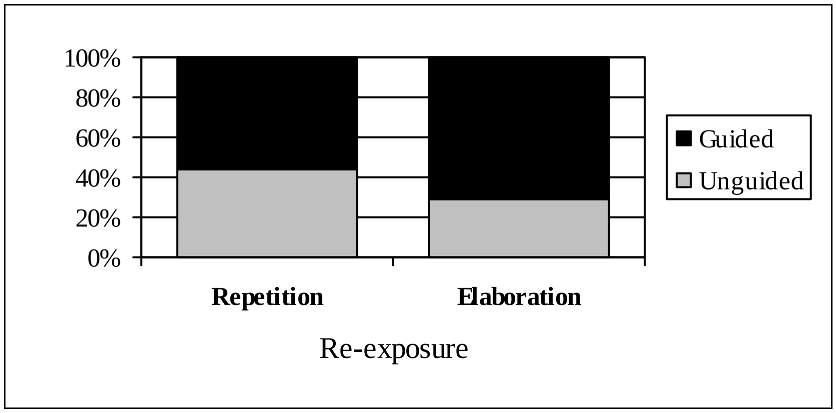

Figure 19. Amount of guidance given, based on re-exposure method utilized.

As indicated by Figure 20, both instructional strategies (guided and unguided learning) used cueing and no-cueing sufficient amounts of the time. For guided learning, 58.9% included cueing while 41.1% did not. For unguided learning, 48.1% included cueing while 51.9% did not.

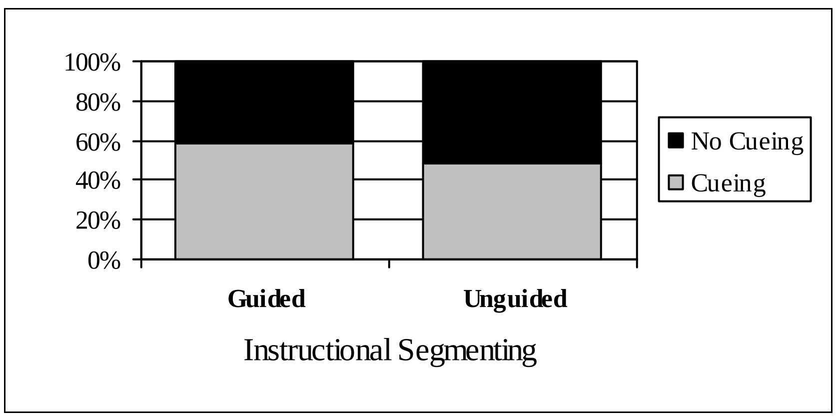

Figure 20. Whether cueing was provided, based on whether guidance was provided.

Player Interaction Mode and Instructional Method Used

Figure 21 shows presentation objects and person-to-object interactions were the dominant vehicles for introducing game elements whenever repetition or elaboration was used in the game as an instructional method. Both player interaction modes were used similar amounts: 52.9% versus 39.1% for presentation objects versus person-to-object interactions, when repetition was used, and 53.1% versus 42.7% for presentation objects versus person-to-object interactions, when elaboration was used.

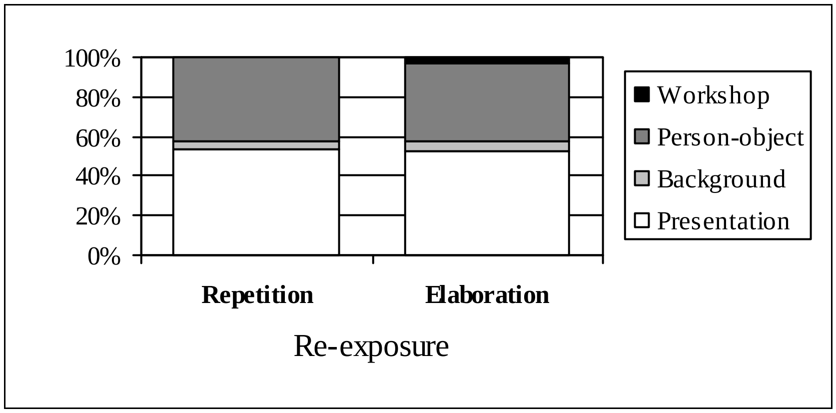

Figure 21. Player interaction mode utilized, based on re-exposure methodology utilized.

Figure 22 shows presentation objects were the dominant mode for introducing game elements, regardless of the type of instructional segmenting used. Person-to-object interactions were also substantially used when part task training was utilized. Person-to-object interactions were nearly sufficiently used when part-whole training was utilized (24.3%).

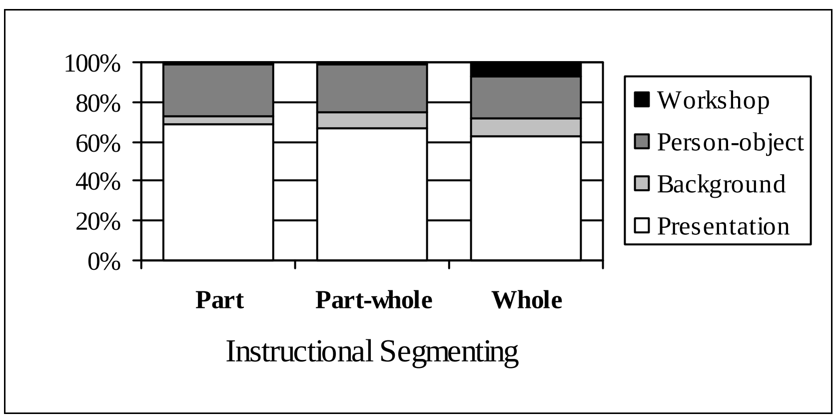

Figure 22. Player interaction mode utilized, based on instructional segmenting.

As can be seen in Figure 23, regardless of whether instruction was provided via pre-training or just-in-time training, presentation objects were the dominant player interaction mode.

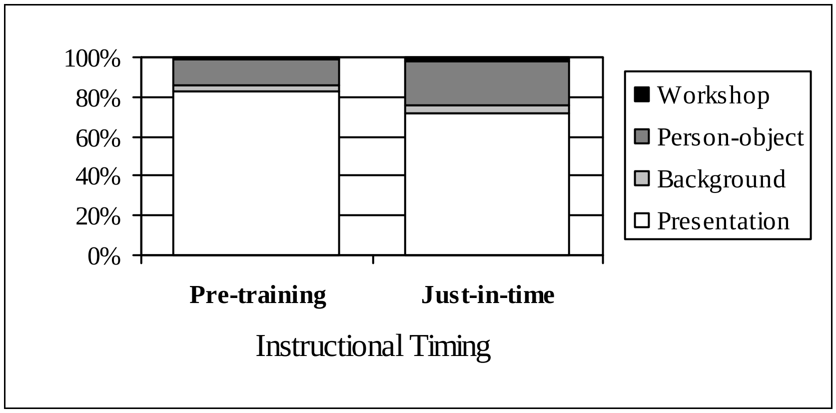

Figure 23. Player interaction mode utilized, based on timing of instruction.

Instructional Segmenting and Instructional Method Used

As shown in Figure 24, regardless of whether instruction was provided via pre-training or just-in-time training, part task training was the dominant form of instructional segmenting.

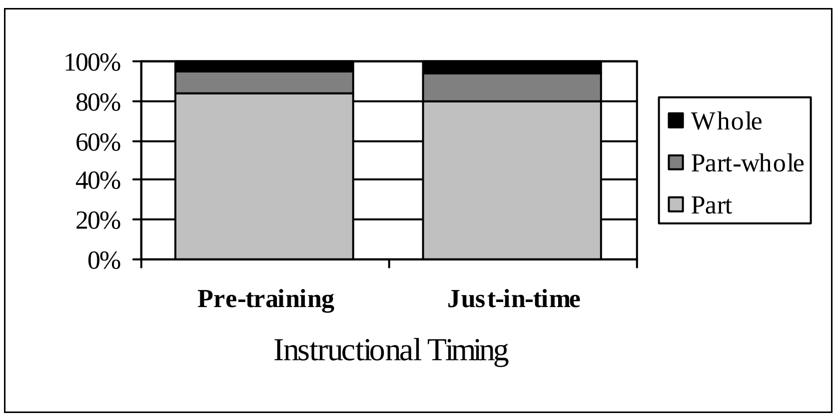

Figure 24. Type of instruction segmenting utilized, based on the timing of instruction.

As indicated by Figure 25, regardless of which instructional segmenting approach was used (part, part-whole, or whole task learning), sometimes cueing was provided while at other times it was not. However, the three segmenting approaches did vary in terms of the form of cueing (cueing versus no cueing). For part task instruction, cueing was provided more often, as compared to no cueing (61.5% versus 38.5%, respectively). For part-whole task instruction, there was similar use of cueing versus no cueing (57.7% versus 42.3%, respectively). For whole task training, cueing was used less often than no cueing (35.2% and 64.8%, respectively).

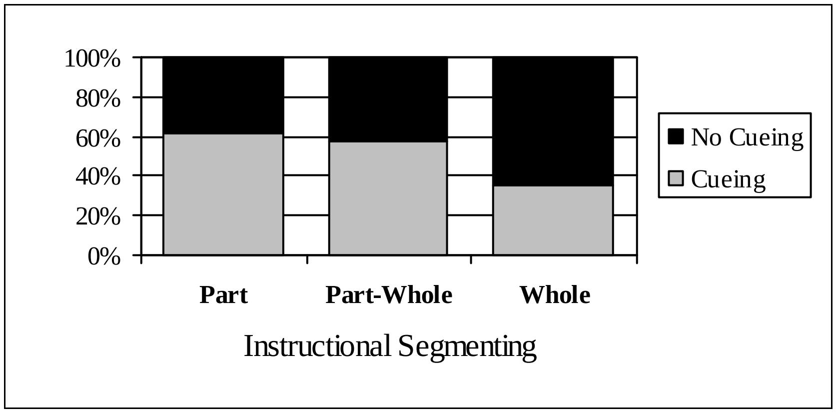

Figure 25. Whether cueing was provided, based on whether guidance was provided.

Type of Re-exposure and Instructional Method Used

Figure 26 shows that pre-training utilized comparable amounts of elaboration and repetition (46.7% and 53.3%, respectively), while just-in time training utilized more elaboration then repetition (62.3% and 37.7%, respectively).

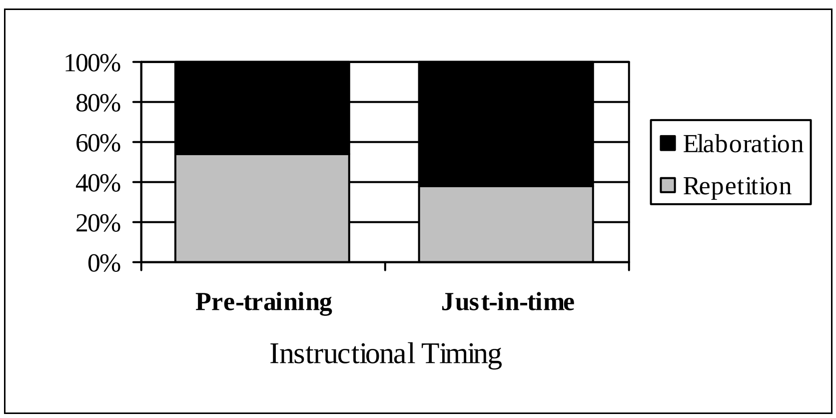

Figure 26. Type of re-exposure methodology utilized, based on the timing of instruction.

As shown in Figure 27, all forms of instructional segmenting (part, part-whole, and whole task) utilized both elaboration and repetition, with repetition utilized more often, compared to elaboration.

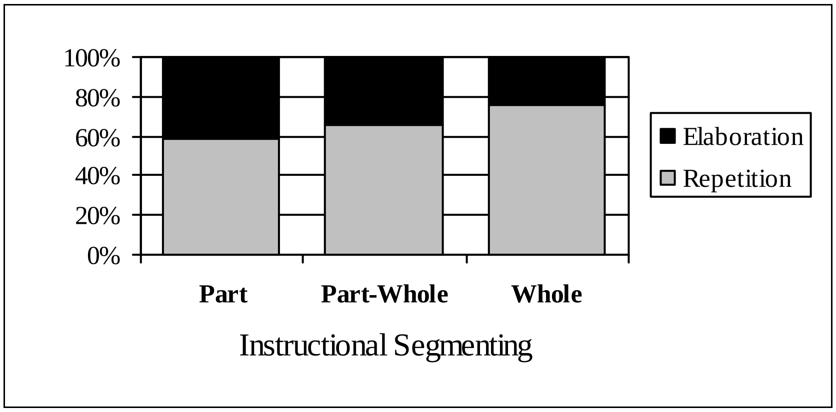

Figure 27. Type of re-exposure methodology, based on the segmenting of instruction.

A number of codes were not included in this paper. Worked examples were not utilized a sufficient number of times to be analyzed and, therefore, were also not analyzed. Furthermore, because games often utilized one dialog screen, list, or chart for multiple purposes (e.g., an advance organizer might also be utilized as a task list or a goal list), there was too much coding overlap for the following instructional features to effectively determine which category an event should be associated with:

- Task list
- Resource list
- Advance organizer
- Implicit or explicit goal

Discussion

Analysis of the 34 popular commercial games resulted in clear delineation across the various instructional methods and instructional strategy for when each is or is ’not typically utilized, depending on what is being taught, how it ‘is presented to the player, or which other instructional method or strategy is being utilized. Earlier in this paper, we explained that 25% was our demarcation for consideration as a viable instructional method. To provide a range of recommendations, from poor to best, we propose the following four categories:

1. Less than 25% = not recommended
2. 25% to 39% = moderately recommended
3. 40% to 59% = strongly recommended
4. 60% or greater = highly recommended

Based on the results of the data analyses, we have created a series of tables (Table 2 through Table 7) that represent useful views for instructional prescription. Table 2 shows all six game play elements (the columns) mapped against all instructional features for which the games were analyzed (the rows). The instructional features are organized by instructional category: mode of interaction, scaffold, strategy, parceling, and timing. In the table, *** indicates a *highly recommended* match, ** indicates a *strongly recommended* match, * indicates a *moderately recommended* match, and a dash indicates a *weak* match or *not recommended* match. For example, part task training is highly recommended to segment the teaching of constraints (3 asterisks), while both part-whole and whole task training are not recommended (a dash). Both repetition and elaboration are considered effective ways to reinforce psychomotor skills; however, repetition is preferred over elaboration (strongly recommended versus moderately recommended, respectively). Table 2 (see the following page) is based on the results shown in Figures 4 through 10:

Table 2

The Six Game Play Components Mapped to Various Instructional Features

Instructional feature	Game play component					
	Psychomotor	Tasks	Constraints	Tools	State	World space
Mode of interaction						
Presentation	♦♦♦	♦♦♦	♦♦	♦♦	♦♦♦	♦♦♦
Person to object	♦	-	♦	♦	-	-
Workshop	-	-	-	-	-	-
Background	-	-	-	-	-	-
Instructional scaffold						
Cueing	-	-	-	-	-	-
Repetition	♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦
Elaboration	♦	♦	♦	♦	♦♦	♦♦
Implicit feedback	♦♦♦	♦♦♦	♦♦	♦	♦♦	♦
Simple explicit feedback	♦	♦	♦	♦♦	♦	♦♦
Elaborated feedback	-	-	-	-	-	-
Amount of guidance						
Guided	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦
Unguided	♦	-	♦	-	-	-
Instructional segmenting						
Part task	♦♦♦	♦♦	♦♦♦	♦♦	♦♦♦	♦♦
Part-whole	-	♦	-	♦	-	♦
Whole task	-	-	-	-	-	-
Instructional timing						
Pre-training	♦	♦♦♦	♦♦	♦♦	♦♦♦	-
Just-in-time	♦♦♦	♦	♦♦	♦♦	-	♦♦♦

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Table 3 shows which of the various instructional methods or strategies are recommended when using the various player interaction modes. Table 3 is based on the results shown in Figures 13, 16, 21, 22, and 23.

Table 3

The Four Player Interaction Modes Mapped to Various Instructional Methods and Strategies

	Player interaction mode			
Instructional method/strategy	Presentation	Background	Person to object	Workshop
Instructional scaffold				
Repetition	♦♦	-	♦♦	-
Elaboration	♦♦	-	♦♦	-
Implicit feedback	♦♦♦	♦♦	♦♦	♦♦♦
Simple explicit feedback	♦	♦	♦♦	-
Elaborated feedback	-	-	-	-
Amount of guidance				
Guided	♦♦♦	♦♦♦	♦♦♦	♦♦
Unguided	-	-	♦	♦♦
Instructional segmenting				
Part task	♦♦♦	-	♦	-
Part-whole	♦♦♦	-	-	-
Whole task	♦♦♦	-	-	-
Instructional timing				
Pre-training	♦♦♦	-	-	-
Just-in-time	♦♦♦	-	-	-

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Table 4 shows which instructional methods or strategies are recommended when using different forms of feedback. Although, it might be more practical to view this table as the types of feedback that are recommended for use with the various instructional methods or strategies. For example, for part-task training, implicit feedback is recommended over simple explicit feedback. Table 4 is based on the results shown in Figures 11, 12, 14, and 15.

Table 4

The Three Feedback Types Mapped to Various Instructional Methods and Strategies

	Feedback type		
Instructional method/strategy	Implicit	Simple explicit	Elaboration explicit
Instructional scaffold			
Cueing	-	-	-
Repetition	♦♦♦	♦	-
Elaboration	♦♦♦	♦	-
Amount of guidance			
Guided	♦♦	♦	-
Unguided	♦♦♦	♦	-
Instructional segmenting			
Part task	♦♦♦	♦	-
Part-whole	♦♦	♦♦	-
Whole task	♦	♦♦	-
Instructional timing			
Pre-training	♦♦♦	♦	-
Just-in-time	♦♦♦	♦	-

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Table 5 shows which instructional methods are recommended, depending of the amount of guidance being provided. Table 5 is based on the results shown in Figures 11, 17, 18, 19, and 20.

Table 5

Amount of Guidance Mapped to Various Instructional Methods

	Amount of guidance	
Instructional method	Guided	Unguided
Instructional scaffold		
Cueing	♦♦	♦♦
No cueing	♦♦	♦♦
Repetition	♦♦	♦♦
Elaboration	♦♦	♦♦
Instructional segmenting		
Part task	♦♦♦	-
Part-whole	♦♦♦	-
Whole task	♦♦♦	-
Instructional timing		
Pre-training	♦♦♦	-
Just-in-time	♦♦♦	-

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Table 6 shows which instructional methods or strategies are recommended based on the type of instructional segmenting being used. Table 6 is based on the results shown in Figures 12, 18, 24, 25, and 27.

Table 6

The Type of Instructional Segmentation Mapped to Various Instructional Methods and Strategies

	Instructional segmenting		
Instructional method/strategy	Part-task	Part-whole	Whole
Instructional scaffold			
Cueing	♦♦♦	♦♦	♦♦♦
No cueing	♦	♦	♦♦♦
Repetition	♦♦	♦♦♦	♦♦♦
Elaboration	♦♦	♦♦	-
Implicit feedback	♦♦♦	♦♦	♦♦
Simple explicit feedback	♦♦	♦♦	♦♦
Elaborated feedback	-	-	-
Amount of guidance			
Guided	♦♦♦	♦♦♦	♦♦♦
Unguided	-	-	-
Instructional timing			
Pre-training	♦♦♦	-	-
Just-in-time	♦♦♦	-	-

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Table 7 shows which instructional methods or strategies are recommended based on the timing of the instruction. Table 7 is based on the results shown in Figure 14, 17, 24, and 26.

Table 7

Timing of Instruction Mapped to Various Instructional Methods

Instructional method	Instructional timing	
	Pre-training	Just-in-time
Instructional scaffold		
Cueing	-	-
No cueing	-	-
Repetition	♦♦	♦
Elaboration	♦♦	♦♦♦
Implicit feedback	♦♦♦	♦♦♦
Simple explicit feedback	♦	♦
Elaborated feedback	-	-
Amount of guidance		
Guided	♦♦♦	♦♦♦
Unguided	-	-
Instructional segmenting		
Part task	♦♦♦	♦♦♦
Part-whole	-	-
Whole task	-	-
Instructional timing		
Pre-training	-	-
Just-in-time	-	-

♦♦♦ = Highly recommended match. ♦♦ = Strongly recommended match. ♦ = Moderately recommended match. - = Weak match or not recommended match.

Conclusions and Implications

As stated at the beginning of this report, we contend that one of the reasons certain commercial video games are popular is they effectively teach players how to play the game. This claim was supported by a recent study by Wainess et al. (2011). The games that matched methods recommended in Tables 2 through 7 were easier to learn than those that did not.

While Tables 2 through 7 enable a quick selection of appropriate instructional methods or strategies for game designers, they can potentially serve as a far more useful tool. As argued earlier in this report, for games to be effective learning environments, game instruction and domain instruction must be integrated. This, in part, is achieved by using the same set of instructional methods and strategies for both learning the game and the domain. When developing a game for learning, both game designers and instructional designers can use Tables 2 through 7 to determine the best methods for teaching a particular game play element or instructional domain element. For game play elements, the tables are used as described in this paper. For instructional domain elements, one simply needs to map the instructional elements to the game play elements (e.g., what is a learning domain analog to a psychomotor skill or to a constraint) (rule). Table 8 provides two examples of how the game play elements (column 1) can be mapped to learning domains and to instructional elements (columns 2 and 3).

Table 8

Instructional Domain Examples of the Six Game Play Elements

Game play components	Math domain examples	Learning to fly an aircraft examples
Psychomotor skills	• Counting with fingers	• Manipulating the flight controls
Tasks (goals)	• You must solve for X • You must determine the time it will take to go from Chicago to New York	• You must take off and land successfully • You must fly to three different airports
Constraints (rules)	• You must use common denominators when adding fractions • A triangle has three sides	• What keeps an aircraft from falling • How weather affects flight
Tools	• How to use a calculator • Times tables • Formulas, such as $A = \pi r^2$	• How to use a radio • How to use GPS
State (player state)	• Showing what' is still needed to solve the current problem • How far you have traveled • How fast you are moving	• How long until you land • Whether you are on the correct heading • Whether you have been given permission to land
World space (viewing and monitoring)	• How have your actions impacted the world • A game world visualization of the problem space	• Understanding the instrument panel • Knowing the surrounding weather

For learning games to effectively integrate game learning and domain learning, game designers and instructional designers will need to work closely during the design and development process. Instructional designers must determine which instructional methods and strategies are best suited to the to-be-learned materials. They must also decide the order(s) in which the information is best learned. This leads to a list of instructional methods and strategies that a game designer will need to utilize as well as the order in which different instructional methods and strategies will be used. The game designer must take this information and build a game that utilizes the same instructional methods and strategies; however, this is not a simple design task.

The requirements of following a desired instructional path may constrain a game designer to the point where an interesting or fun game cannot be achieved. Compromises are likely to be needed. That is, for a game to be interesting and engaging, the optimal learning path or the optimal learning approach (instructional methods and strategies) will likely not be achievable. More than likely, the game designer will require changes to instructional choices in order to make a coherent game. This begins the back and forth redesign and renegotiation that must become the iterative process of the design and development of games for learning. Without this give and take, a fully integrated game (with seamless integration of the game and the learning domain) cannot be achieved. In addition, without this give and take, an engaging game that is also an effective learning environment will likely not be achieved.

Lastly, it is important to note that, while the methods and strategies utilized by popular video games for teaching how to play the game are part of why those games were popular, they should only be considered guidelines, not rules, to which methods and strategies should be employed for teaching the instructional domain content in a game for learning. For instance, video games use very little explicit elaborated feedback. This is likely because too much detailed feedback would make a commercial video game less fun. Commercial video games also use more repetition than elaboration. This is possibly because commercial video games are won primarily by automation (e.g., gaining quick reflexes) and chunking (e.g., developing a relatively small number of strategies or procedures that can be rapidly called upon), both of which are fostered by repetition. Winning in a commercial video game has little to do with transfer or using what was learned in novel situations or settings (Brunken et al., 2003; Mayer & Moreno, 2003). The learning tasks and the knowledge and skills development in commercial video games are, compared to the learning required for most instructional domains, relatively trivial. In addition, they are not expected to be transferred across games. By contrast, instructional domains are not trivial and transfer is an important outcome of the learning process. The amount of instruction needed for a learning domain, and the amount of support needed during the learning process is much greater than the amount of instruction and support needed for a commercial video game. So while we would recommend that instructional developers use the information and reference tables provided in this report as guides when designing domain instruction for learning games, they should not feel bound by the tables. If possible, follow the guidelines provided here; however, when the needs of learning conflict with the type or amount of support used in commercial video games, remember that you are not designing a commercial video game—rather, you are designing a learning game.

Scholarly Significance

As interest in games for learning increases in the learning community, methods that will facilitate the development of effective games for learning are essential. An important outcome of this research is that both traditional and instructional game designers will have a tool that defines both optimal and less optimal ways of teaching. The research may help each designer determine best practices in terms of his own instructional needs; moreover, the research provides designers with a methodology for matching instructional methods and strategies—which will ultimately result in better blending of the two instructional tasks.

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Appendix

Table A1

Instructional Methods and Strategies: Definitions and Examples

Method/strategy	Definition	Example(s)
Repetition	Doing something you've done before	Using a mouse/keys/controller to move a game character on the screen. Every time you do it you're doing repetition (repeating what you've done before).
Elaboration	Doing something you've done before, but in a different way; often combining it with other knowledge or skills.	An example of doing what you've done but in a different way: After learning to move a game character with the mouse/keys/controller on flat ground, you use the same methods to move the character up hills, down into valleys, up ramps, up stairs, etc. An example of combining what you've done with other things: You had learned to run up a ramp and you had learned to jump. Now you have to run up a ramp and, while running, jump from that ramp to another ramp.
Part task training	You're taught by learning to do only one thing at a time.	You learn to throw while standing still. You learn to pick up something or put it down. You learn to duck down. You learn to move sideways along a wall.
Part-whole task training	You're taught an entire complex task but only have to focus on a part of the task.	You're given a flying vehicle that also has a lot of weapons but you begin by only learning to fly. Then later, you learn to evade enemies; even later, you learn to use the weapons.
Whole task training	You must do the whole task and focus on all its parts.	You're given a race car and you're expected to practice everything related to driving (turn, increase/decrease speed, stop, pass other cars, etc.) until you get good at it.
Pre-training	Training before you begin something, so you begin with a particular level of skills or knowledge.	In a game where you need to use various weapon types (e.g., shooting, throwing, swinging), you are given training and practice with at least one of each type of weapon, so you know what to do when you encounter these or similar kinds of weapons in the game.
Just-in-time training	You received training when you need to use it, rather than learning it earlier and having to remember what to do.	You get to a river where you need to bring a boat from the far side of the river to your side so you can get into it. There are instructions next to the boat dock explaining which levers to pull and which wheels to rotate in order to get the boat to your side of the river.
Worked example	You are given step-by-step instructions on how to do something.	(1) You jump onto a speedboat. To start the engine, you look at a diagram that shows which buttons to press, how far to pull levers, the pedals to push, and the order in which to do each of these things. (2) You already know how to run and jump. Someone runs by you and runs and jumps his way all the way to the top of a high structure, looks back at you, and jumps over the structure and disappears. That person just showed you what to do but you have to figure out the details of the steps. This is not a well designed worked example but a common one in games.

Method/strategy	Definition	Example(s)
Advance organizer	Something that tells you what you're going to be doing.	A character or a piece of text tells you about the mission you're going on and what you will need to accomplish to complete the mission.
Task list	Something that lets you know how much you've accomplished and what's left.	Related to the advance organizer, this is a check list that either you need to check off or that is checked off for you, so you know what you've done and what remains to be done.
Implicit feedback	Indirect indication of something working or not working, something being done correctly or incorrectly, etc.	(1) If a door doesn't open, that's a clue: the door may be stuck; you may need a key; it's a fake door. (2) If you press a button and nothing happens, you know that either nothing happened or something happened and you're just not aware of it.
Simple explicit feedback	An obvious indication of something working or not working, something being done correctly or incorrectly, etc. but with NO specific details.	(1) You enter a code on a safe's keypad and the safe opens. (2) You turn a key in a door and the key doesn't work. (3) You answer an oracle's riddle and the oracle tells you that you answered it incorrectly. (4) You enter a room and an alarm goes off. (5) You press a button and it lights up.
Elaborated explicit feedback	An obvious indication of something working or not working, something being done correctly or incorrectly, etc. but WITH specific details.	(1) You try to open a door and it doesn't open. A message pops up stating that a key is needed and it's somewhere in the room. (2) You press a button, it lights up, an alarm sounds, and you hear "the missile launch countdown has begin, 10…9…8…."
Cueing and pointers	Letting you know something is important; to help you with attention and selection.	(1) Lighting the part of a scene you're supposed to head toward, and to help you avoid the dark areas. (2) Have a sound play whenever the enemy approaches. (3) A health indicator. (4) A display showing the location of your troops and enemy troops. (5) Glowing and spinning items that indicate things you're supposed to either go up to or pick up.
Guided learning	When you're given support during the learning process.	Each of the above instructional methods are examples of support during learning. More support = more guidance. Among the most critical supports are goals (knowing what to do), advance organizers and task lists (knowing the steps involved and which ones you've already done), and attention and selection assistance (knowing what's important and which items you need to interact with).
Unguided learning	When you are given minimal or no support during the learning process.	You come up with your own goals and your own tasks for accomplishing the goals; it's up to you to keep track of what you've done and to figure out what's important.