Evaluating Interactive Entertainment using Breakdown: Understanding Embodied Learning in Video Games

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ABSTRACT
This paper describes evaluating interactive entertainment by understanding embodied learning in games, which is a perspective that situates the learning that a player must go through to play a game in a skill-based environment. Our goal was to arrive at a tool for designers to improve learnability from this perspective. To study embodied learning, we use the concept of breakdown, which happens when our experience fails to aid our everyday actions and decision-making. We conducted a study to investigate learning in games from which we constructed a framework of 17 patterns of breakdown and a set of guidelines to aid heuristic evaluation of video games and to help designers support *breakdown in interactions*, which support players' learning, so that they do not become *breakdowns in illusion*, which break players' immersion [19].

Author Keywords
video games, user experience, learnability, embodied interaction, flow, immersion, entertainment

INTRODUCTION
At the heart of the gameplay experience is an inherent challenge with which players must grapple to play a game. This non-obvious design strategy makes games interesting to play and runs counter to the more typical guideline that usable software must provide minimally frustrating experiences that are transparent to the user. Thus, games have become unique challenges to designers because games must be non-transparent and non-obvious to the player even though it has been shown that games can benefit from a certain amount of usability and learnability [17; 22]. Moreover, the complex environments of games still need to be capable of being learned by a certain audience. So, when designing games, there is a tension between challenge and learning that must be addressed.

We explore this learning from an embodied perspective in this paper. Embodied learning means that our learning relies on our perspective in an environment such that what we learn and what perspective we have *on learning* depends on our actions and engagement in the environment. It is argued in this paper that when players have deeper, more meaningful, embodied experiences with a game like *Tetris*, for instance, they get closer to understanding the rules that support the underlying interaction and can play this game more effectively and enjoyably. At the same time, this deep understanding of the underlying rules expands players' *domains of experience*, altering the ease with which they play other games as well.

This paper will analyze why some people find it easy to learn new games, while others find it incredibly difficult. To do this, we will need to analyze breakdown in games when actions we take to accomplish some task no longer seems to work. In the context of education, we might call these "teaching moments" where, through misunderstandings, underlying assumptions and expectations about a problem are revealed to students and they must develop new metacognitive strategies to work through the problem with the help of a mentor. We, as designers, also can engage with these opportunities to reach players who may become frustrated with a particular game because it does not conform to their preconceived expectations about how the game should perform.

The *goal* of this paper is to propose a strategy for guiding the design of interactive entertainment, video games, and learning experiences using technology from this learning perspective. This heuristic strategy will evaluate aspects of an environment that under certain conditions can lead to the natural breakdown that occurs through learning—described as a *breakdown in interaction*—so that we can potentially avoid losing immersion in the game—described as *breakdown in illusion* [19]. For instance, let us assume that we have a game that requires us to open a locked door to proceed to the next section. Convention dictates that the player needs to find the right key for that door. An experienced player would ruminate over the following possibilities to locate it: previous items collected in the inventory, nearby characters with whom he or she can talk, nearby treasure chests, previously unfinished quests, and so forth. For inexperienced players, this example reveals many assumptions about what they can figure out to do next. The proposed strategy would expose these assumptions to improve game design for all types of users.

We explain our arrival at a heuristic framework for supporting *breakdowns in interaction* through design in the following sections. The first section describes the

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theoretical sources that support these concepts. The second describes a study that observed players of varying levels of experience playing unfamiliar games. The third section describes the framework organized from themes in the study. Finally, the paper ends with a proposal for applying the findings of this study to future game designs through the method of heuristic analysis.

THEORETICAL BACKGROUND

There are several terms used throughout this paper that are shaping this research: *embodiment*, *domain of experience*, *breakdown*, and *flow*. We will provide our interpretation of what these terms mean and how we use them in this paper.

Embodiment

Within embodiment, there are two threads of discourse. The first is the embodied cognitive thread grounded in cognitive science, which generally follows from the work of Husserl. The second is an embodied phenomenology grounded more on hermeneutics and the work of Heidegger. While we find the former insightful at times, it is the latter perspective that we base our discussion of embodiment in this paper. In general, the embodied perspective focuses on the interrelation of thought and action. Embodiment describes a shift in the notion of interaction from analyzing the device and user separately towards an integrated analysis of both in interaction with each other [2; 5]. [10] described the phenomenon of embodied interaction through its participative nature emphasizing the importance of the environment as it shapes the meaning of a given interaction through users' participation in that system. He also emphasizes that embodiment is not necessarily tied to a physical body, though it usually is. [23] describe how although [10] describes that virtual environments often ignore the embodied-ness of interaction, games often provide contexts for making actions taken in their spaces meaningful and embodied within that constrained space. [1], also, brings this notion of embodiment to gameplay. He highlights the concepts of mapping of the user to various levels of the interface (such as the controls, GUI, and game rules) and affordance for making sense of the game environment. [29] describe the notion of the enaction of the embodied self-arguing that, through our engagement and participation in the world, we enact who we are and the experience of the world as it unfolds. Finally, [20] describe the importance of understanding the immediacy and complexity of experience in HCI research, which necessarily implies an embodied perspective to have that experience. Altogether, this theory supports the notion that embodiment is the state of having a perspective in an environment with the capability to both change that environment and be changed by it.

Domain of Experience

When taking actions in a technological environment, users rely on *domains of experience* to make sense of the variety of interfaces they use. They leverage prior knowledge of some area such as games and are crucial for expanding that knowledge into new interfaces [4]. [14] explains that knowledge and experience in games form around domains in which an individual can act upon that knowledge. These domains are contexts in which our knowledge and actions acquire meaning.

The situated action perspective, which emphasizes the importance of context for the creation of new tools, sheds some light on *domains of experience*. This perspective states that use always shapes the perception of a devices and the space of what is possible using them [3; 27]. Knowing a tool through its use gives rise to a personal embodied knowledge that people develop through embodied learning within a *domain of experience*. It is possible, however, to abstract general understandings from these experiences about a class of related phenomena (e.g., [15] describes inscribed and incorporating practices and [26] describes syntactic and semantic knowledge). [31] describe the importance of reflection upon gameplay as important for developing metacognitive capabilities to improve learning of a game. This reflection is yet another way that one can expand his or her *domain of experience*. The *domain of experience* that we derive through an embodied experience allows us to change our understanding about past, present, and future such that we alter our expectations of what is to come [18].

Breakdown

Oftentimes, situations occur that are outside our *domain of experience*; this is the realm of breakdown. Breakdown is a notion that originates in the phenomenology of [16] where he describes the connection between a device and the user according to two conditions: readiness-at-hand and presence-to-hand. When users experience a device (e.g., a video game) as ready-at-hand, the focus of their attention is on the activities they are doing and not consciously on the device itself. In a sense, the device becomes an extension of the user. When they experience the device as present-to-hand, however, they focus specifically on the device, which has gone from being an extension to being a hindrance as they try to resolve whatever is preventing readiness-at-hand of the device. The consequence of this transition from

Figure 1. Playing all 5 keys in Guitar Hero using 4 fingers. © Copyright 2005 *RedOctane*.

ready-at-hand to present-to-hand is called breakdown [30].

When breakdown occurs, we must form new strategies to cope with changing conditions. For example, consider how an increase in the difficulty of a game forces us to change our strategy. In *Guitar Hero*, this change of strategy is evident when we *advance* to play all five notes using only four fingers, while we only needed to play three or four notes before (see fig. 1). When changing strategies, we are supported by training and tutorials, playful exploration of the environment, and social guidance. Training is a part of the design of many video games; however, it may not be valid to assume that training is always used or remembered. Playful exploration is a characteristic of an individual and the extent to which they use the environment to externalize their strategy [5; 24] through thoughtful trial and error. The last is a feature of a player's social environment and, while important, is outside the scope of this study. This model of breakdown is how we will analyze learning in video games.

Flow

Finally, *flow* is the sense of immersion that we maintain by our engagement through this whole process. [6] explains that for this to occur the challenges of an activity must be balanced with the skills of the player. For this reason, a completely transparent game will not provide an adequate user experience. [25] extended this notion to video games to show how those skills rely on a literacy that develops in parallel with this state of *flow*, which is similar to the *domain of experience* described above. By overcoming these obstacles and developing an increasingly embodied experience of the game world, players benefit psychologically through *flow* from completing objectives.

From states of flow that we experience when we play games, there are two levels at which breakdown can occur [19]. The first is *breakdown in interaction*, which forces players to develop new strategies, and is a part of normal gameplay. Flow, however, is maintained in this breakdown. This level helps players to generalize experiences in gameplay and to become better players. The second is *breakdown in illusion*, which happens when players become so disconnected with the unfamiliar functioning of the virtual environment that they are thrust out of the state of flow. We argue that usability specialists have been successful at minimizing *breakdowns in illusion* in software systems, but they have not always been successful at supporting *breakdowns in interaction*, nor necessarily have they been aware of its existence.

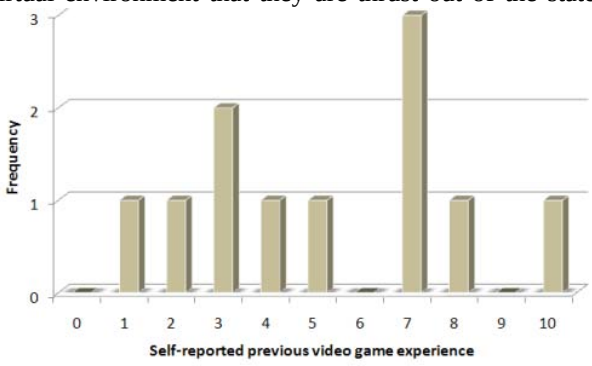

Figure 2. Histogram of the frequencies of previous video game playing experience (ability).

A STUDY OF BREAKDOWN IN GAMES

The study for this paper was conducted to ask the question: why do certain people succeed at games so easily, while others struggle greatly despite their best efforts? It put players of varying abilities in situations that they were unfamiliar with to encourage breakdown to occur.

Participants

Participants for this study were recruited from members of Indiana University. We had personal relationships with all the participants in the study, which we saw as a strength of the research design since it afforded a level of comfort between researchers and participants to encourage participants to talk about their experience. Thirteen people participated in the study (eight male, five female) with an even split in self-reported previous level of video game experience (see fig. 2).

Study Design and Methods

Whereas [19] took a more computational approach to analyzing the moments when breakdown occurred, we wanted to address this issue from the standpoint of each user's experience. We relied on the technique of heterophenomenology, which studies other's experiences through third-person, anthropological interview [7]. Modifying this approach for a game play study, we were able to understand with participants help how their embodied learning unfolded. The approach taken in this paper is very similar to the ethnomethodological approach in Counter-Strike performed by [23]. Such a method focuses on the phenomenological "organization of the experiential, but makes it an empirical rather than a philosophical engagement," (p. 207). Their focus on gradual learning and sense-making about map terrains, skill development, and social coordination corresponds with this paper in all respects except social coordination even though their focus was on expertise in playing Counter-strike while ours was on players playing games with which they did not have much experience.

In our study, each session took approximately three hours. The study began with an initial interview that was used to gauge the participant's experience with various genres of games. We asked participants questions such as:

- How often do you play video games?
- What games have you played in different genres of video games?
- How would you rate your experience with video games on a scale from 1-10? computer technology in general?

Based on this interview, one to two video games were selected for participants to play from Table 1, which we assigned based on the genres with which they had little experience. While playing the games, we asked participants to talk-aloud, while we asked questions about their experiences. For the study, we needed to be both very experienced with the game to understand designers' expectations and to ask naïve questions to understand players' experiences. Through this deeply interpretive study, we wanted to analyze these patterns of expectations of both players and designers and where they did not align.

We identified breakdown both by asking participants and through subtle non-conscious indicators including expressions of surprise (e.g., "What?" and "Ohhhh!"), behavior changes from game feedback, particularly erratic or wandering behavior, and thoughtful trial and error behavior while trying to accomplish a task. Furthermore, breakdown manifested itself in the players' gameplay through frustration due to confusion and also accidental discoveries of affordances. Frustration occurred when players could not figure out how to accomplish a task, while accidental discoveries occurred when they learned something new unexpectedly. We concluded study sessions with debriefing questions about their experience.

We used a method of analysis described in the CSCW literature for communicative breakdown. [28] describe "breakdown analysis" as the procedure for "assist[ing] the evaluator in identifying [a breakdown's] underlying cause," (p. 286). The three stages of breakdown analysis include transcription and categorization of breakdowns, causal diagnosis, and remedy prescription. For this study a full transcription was not performed, but screenshots, voice recordings, and field notes were analyzed side-by-side to detect and categorize patterns of breakdown using the field note classification process described in [13] for analyzing anthropological field notes. To the extent that the data provided causal connections, such connections were identified below relying largely on the talk-aloud component of the study for user's reasoning for breakdowns in their expectations. Finally, design guidelines described were generated from this analysis. This procedure allowed both the structure of working with patterns of breakdowns and also flexibility in allowing the meaning behind the experiences underlying the patterns to emerge through the heterophenomenological approach.

Table 1. List of games used for the study.

Title	Times Played	Closest Genre
Age of Empires III	2	Strategy
Civilization IV	1	Strategy
CSI: Miami	1	Adventure
Fable	1	Action/Role-playing Game
Final Fantasy X	2	Role-playing Game
Gladius	1	Role-playing Game
Grand Theft Auto	1	Action/Adventure
Half Life 2	2	First-person Shooter
Indigo Prophecy	2	Adventure
Morrowind	1	Role-playing Game
Myst V	1	Adventure
NeverWinter Nights	1	Role-playing Game
Rockstar Manager	1	Simulation
The Sims 2	2	Simulation
Sly 2	1	Platformer
Sonic Heroes	1	Platformer
SSX 3	1	Sports/Racing

PATTERNS OF BREAKDOWN

Through our analysis, we arrived at a list of seventeen patterns of breakdowns. They were grouped into four categories: perceiving the environment, developing strategy, taking action, and meaning making (see fig. 3). While the reader may be able to think of some other potential breakdowns, this is the list at which we arrived in the process of conducting this study—the list is not exhaustive, but it is exhaustively descriptive of the study performed. In this section, we will describe each category and the likely causes as well as provide an example for each. In the next section, we will describe a framework for controlling the effects of these breakdowns in the design of new games.

Perceiving the Environment

Breakdowns involved in perceiving the environment revolved around a player's ability to sense the environment and what it offers. There are four patterns related to this category including breakdowns of *cues & affordances*, *cut scene transitions*, *camera & navigation*, and *depth*. *Cues & affordances* related to the way that the mouse or objects in the environment change as a user hovered over them. In normal operation, we use these cues to understand how the environment is organized and also to generate crude expectations about the environment when certain actions are taken. If it is either unclear what a certain cue means, or these cues becomes too hidden for a player to figure out, breakdowns *may* ensue. Second, *cut scene transitions* occurred as players transitioned from being passive observers of a short narrative to active participants in the related game. Two types of cut scene transitions included games such as *Grand Theft Auto* and *Fable* situating the cut scene in the actual scene itself and also *Sly 2*, which cuts away from the action while still remaining in the diegesis—narrative world—using binoculars as the means for enacting the cut scene (see fig. 5). While these transitions usually led to momentary lapses where players realize that they now

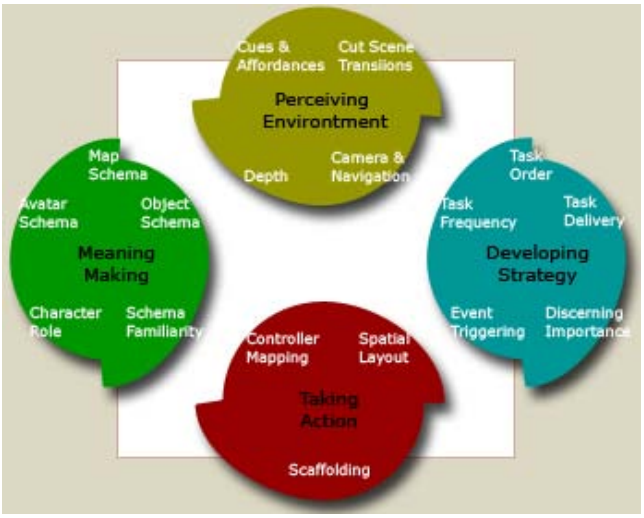

Figure 3. Four categories and seventeen patterns of breakdown observed from study.

control the character, more confusing cut scenes actually took control away from the player (e.g., tutorials such as *Civilization IV* and *Final Fantasy X*'s sphere grid).

The remaining two patterns of *camera & navigation* and *depth* dealt with resolving issues related to the viewpoint. Games accomplished player navigation either by yoking the viewpoint of the camera and the orientation of the player together in one control or by using two separate controls for each. The first time a player transitions into this second type of control scheme can be very intimidating if they are forced to control both at the same time to accomplish a task. Finally, breakdowns of depth specifically occurred in first-person perspectives where players needed to navigate around a cluttered environment, but kept snagging on objects that were not in their field of view. While this can be annoying for people with experience, it can lead to major failures for novices.

An example that encapsulates these breakdowns from the study occurred for a player playing *Myst*. After a short narrative introducing the game, the player found himself in a room with no apparent exits. The player found several objects with which he could interact, but nothing that moved him to the next part. For about the next ten minutes, the player randomly clicked all over the screen rather than relying on cues given by the game, until he finally found a small little knob that changed the hand icon of the mouse into a hand pushing on the knob. *Myst* clearly relies on small puzzles such as this to challenge the player, but it was clear that the player was getting frustrated with the game even 10 minutes into it allowing a *breakdown in illusion* to occur. After this rocky start, the rest of the session went better, but there is always a risk on the part of the game designer that a player will quit playing before getting into a flow with the game.

Developing Strategy

Developing strategy breakdowns occurred when players determined what actions to take in the environment and established goals for those actions. The five patterns of breakdown in this category are *task/instruction frequency*, *task/instruction order*, *task/instruction delivery*, *discerning importance*, and *event triggering*. Breakdowns of *task/instruction frequency* related to the cognitive demand put on the user to accomplish a task or to understand an instruction. The level of cognitive demand must remain low enough so that players who are new to a game can understand and generalize from these experiences. This, however, depends on the extent of a game audience's level of experience. In the study, one of the participants who played *Indigo Prophecy* had about one minute to navigate within his character's apartment to perform several small tasks to hide incriminating evidence before police entered the apartment. It took the participant many tries before he developed a strategy that worked by slowly getting to know the apartment and using a strategy that made him better equipped to deal with all issues simultaneously. Second, *task/instruction order* breakdowns involved the order in which tasks and instructions are presented In the study, a participant playing the tutorial in *Gladius* was given a "tip" from the game describing multiplayer matches. At that point, the participant second-guessed whether the next task was to be multiplayer, even though the multiplayer system had nothing to do with his current task. Third, *task/instruction delivery* has to do with how the computer revealed the next task or instruction. *Delivery* breakdowns related to the wording of an instruction or how new instructions were introduced to a player. This included terminology that is unfamiliar for the user and also the location of instructions if they do not appear immediately on the screen.

The previous two patterns had less to do with tasks or instructions and more to do with understanding the actions that could be taken in the environment. *Discerning importance* relates to a player's ability to figure out what objects had value for accomplishing a task, and what objects could be ignored. The ability to quickly distinguish importance helped greatly at relieving the cognitive load of a game when compared to keeping everything in players' memories. Finally, *event triggering* breakdowns occurred when players made causal associations about objects in the environment. From players' perspectives, each player needed to project the possibilities of actions in the game such as, "If I take this apple from the tree, what will happen," and, "How can I make the apple fall from the tree?" The ability to trigger events was tied directly to accomplishing a goal or task in the game. [23] demonstrated how this projecting possibilities in a given environment was crucial for accomplishing improvisational activities especially in games.

An example from the study that shows this category of breakdowns occurred in *SSX 3*. The objective of the game

Figure 4. Developing strategy example of breakdown in *SSX On Tour* © Copyright 2005 *EA Sports*. The game here is different but illustrates the same point.

was to snowboard in a race down the mountain while avoiding obstacles in the path. After some time playing the game, the participant realized that these "obstacles" could actually be used as shortcuts. This realization was not revealed in her strategy until she accidentally rode a railing several times reinforcing this possibility. The strategy began to pay off when, through using these short cuts, she achieved an advantage in the race. This insight transformed her play experience (see fig. 4). In addition, this example showed how the player experienced a breakdown in *discerning importance* to give her a competitive advantage and *triggering events* in realizing how to ride these railings without ever being explicitly told. Note that this was not a *breakdown in illusion*, but rather *breakdown in interaction* to promote better play. Furthermore, this shows the second type of manifestation of breakdown explained above where breakdowns revealed themselves not from frustration due to confusion, but due to accidental discoveries of affordances.

Taking Action

Breakdowns of taking action involved the physical level of manipulating the environment and the basic ability to navigate and to perform various tasks. There are three patterns of breakdown in this category including *controller mapping*, *spatial layout*, and *scaffolding*. C*ontroller mapping* breakdowns happened when a player cannot use or understand the physical controls for accomplishing a task. If severe enough, players focused their attention specifically on the control—and away from the game—to diagnose what went wrong. [1] suggests that true embodiment in virtual environments requires that mappings between controls in the physical world and action in the virtual world to be as natural as possible. For example, controls such as *Playstation 2* controllers and keyboards are natural for users who have played many video games before. *Wii* controllers, on the other hand, which utilize physical movement more than button pressing, seem to be natural for an audience more attuned to remote controls. Next, breakdowns of *spatial layout* dealt with players' abilities to understand and remember the 3D environment in which they were immersed, whether for remembering instructions that require visiting different parts of the island in *Grand Theft Auto*, for finding good camping spots in a game like *CounterStrike*, or for finding shortcuts in racing games like *SSX 3*. Finally, *scaffolding* breakdowns related to the natural progression in difficulty that a player faces as a game proceeds. *Scaffolds* in an instructional sense are supports provided by the learning environment to help learners with a new concept or skill that are then removed. In this respect, games often have tutorials or easy levels that help players learn basic game concepts before they transition into the game itself. However, sometimes a disconnection exists between tutorial and game such that when the player is introduced to the game itself, they feel lost. A participant in the study who "skimmed" through the tutorial of *Age of Empires III* struggled with some of the basic operations later in the game when he had trouble understanding what to do when left on his own, which was, in part, the consequence of his own decisions.

A summative example that describes breakdowns of taking action occurred in *Sly 2*. The participant in this study was given the instruction in Figure 5. While the participant had "jumped" before this early point in the game, it was never formally mapped to any buttons on the controller, which made this instruction confusing (e.g., do you just hit the circle button, or jump then hit the circle button) requiring several minutes of trial and error to resolve. Finally, the player discovered that he needed to hit the square button to jump, and then the circle button to land on the wire. This example showed the consequences of breakdowns in *controller mapping*, but also gave an example of a *scaffold*, which allowed the player to test different actions with minimal consequence. This snag forced the user into a *breakdown in illusion* as they focused their attention on the controller.

Meaning Making

Breakdowns of meaning making occurred when players resolved how the computer represents objects, characters, symbols, and so forth supporting players' abilities to

Figure 5. Taking action example of *breakdown* in *Sly 2*. © Copyright 2002 *SCEA*.

interpret the environment meaningfully and to form expectations about the game. There are five patterns of breakdown in this category including *avatar schema*, *map schema*, *object schema*, *schema familiarity*, and *character role*. *Avatar schema* breakdowns occurred as players decided what character represents players' actions in the game world. Games represent who the player is in game spaces differently based on the structure and mechanics of the game (e.g., the figure-less rotator in *Tetris*, the multiple-unit manager in *Age of Empires III*, the third person perspective avatar of *Final Fantasy X*, or the first person perspective avatar of *Half Life 2*). Players' familiarity with avatar representation can differ dramatically depending on genres with which players are most familiar. Next, *map schema* dealt with exactly how a graphical map relates to the spatial layout of the game. From game to game, how the map is represented varied. In the study, the participant playing *Grand Theft Auto* commented on how much easier the game was once he grasped the content of the game map and the overall spatial layout of the environment.

Third, *object schema* breakdowns occurred as players attempted to understand what objects meant. There was a strong connection between *object representation* breakdowns, *cue & affordance* breakdowns, and deciding what actions to take. An example where this type of *breakdown in interaction* could have led to a learning experience was in *Sims 2*. In this session, the participant placed a sunflower inside their house, deleted it, and finally placed it outside. When asked why she decided to do that, she claimed that sunflowers needed sun, which the game itself did not require. This instance showed that when unspecified, players will bring their own conventions in from the outside world about objects. Next, *Schema familiarity* breakdowns occurred when certain representations, relying on traditionally accepted sets of representations, were unfamiliar to a player. New players or players unfamiliar with a certain genre could be unfamiliar with the way certain things are represented by a game. In a discussion we had with a participant who played *Morrowind*, we found that her view differed dramatically from our interpretations of a chest in the game. While she saw it solely as a decorative object, we saw chests as recognized storage spaces for useful objects. Ultimately, the chest in question contained a key to allow her to continue onto the next section. Finally, *character role* breakdowns dealt with understanding the set of abilities and limitations for each character that they control. Failure to recognize character's abilities and limitations put players at an obvious disadvantage for accomplishing tasks.

An example of this category occurred in *NeverWinter Nights*. In this game, the participant selected a druid character role with its specific abilities and limitations. The player approached the missile weapon trainer, which trained players to use bows and arrows. The trainer told him to hit the target from a distance using one of the missile weapons, but several things went wrong for the player. While the player was able to take into his inventory many different types of weapons, he was only able to equip one specific weapon. The player spent several minutes resolving why he could not equip the larger weapons due to his *character's role*. Eventually, he realized that he could only equip the smaller weapons. This example showed that the player had misconceptions about his *character role* as well as *object schema* (e.g., certain objects were too large for his character to equip) and *schema familiarity* (e.g., druids can only select smaller weapons to balance their ability to cast spells). The player gave no indication that this was a *breakdown in illusion*, but it could have become one.

From this collection of 17 patterns, we see how player inexperience contributes to a misunderstanding about games. We also see areas of design that could be improved to help players learn these environments better. The goal of such design, we argue, should be to create designs that are both pleasurable to all sorts of players and learnable for all sorts of audiences.

A FRAMEWORK FOR DESIGN

Ultimately, the purpose of such an investigation is to understand the embodied learning in games, so that it can be appropriated by the design process to produce (1) more usable games and (2) games that can be designed for wider audiences of varying levels of experience. Table 2 contains a list of 17 general guidelines to improve the learnability/usability of games of all varieties. It includes one guideline for each pattern of breakdown listed above. While *breakdowns of interaction* are a natural part of gameplay, severe *breakdowns of illusion* can send someone out of a state of flow [19]. The guidelines address factors that threaten flow mentioned in the study above.

These guidelines can be used by designers as an evaluative tool to appraise the learnability of a game design (see [17] for a discussion on usability, evaluation, and games). It can be useful to help structure usability evaluations of a game's learnability, but may be especially useful for performing heuristic evaluations. Heuristic evaluations, which are the use of expert evaluations based on a set of agreed upon heuristics, can be performed at any phase of a game's design by evaluating it against a set of guidelines like the ones in Table 2. It can be especially beneficial at stages when design ideas and prototypes are in their crudest form [21]. In addition, heuristics are complementary to the efforts of formal usability testing with users. [9] found that errors found by usability often are missed, but found during heuristic evaluation and vice versa.

Furthermore, there has already been some work at creating standards by which games are evaluated heuristically. [8] compared usability and heuristic evaluation based on a set of principles geared at evaluating playability through categories of game play, game story, game mechanics, and game usability. [12] also arrived at a set of heuristics by

Table 2. Design guidelines focusing on improved learnability.

Perceiving Environment
1. Make sure cues' meanings are clear to the user and that cues are not hidden unless they are connected to the challenge of the game. In which case, hide cues with caution. (Cues & affordances)
2. Transitions should clearly indicate when user action may proceed. Minimize when the game takes control away from the player. (Cut scene transitions)
3. Provide training if the audience will be unfamiliar with the navigation system. Ideally, let the interface conform to both unified and separated styles of navigation and camera manipulation. (Camera & navigation)
4. Minimize clutter in areas where players navigate. (Depth)
Developing Strategy
5. Allow time for new concepts or skills to "sink in" for a player before introducing other new concepts. (Task/instr. frequency)
6. Keep tasks and instructions focused towards the current goal. (Task/instr. order)
7. The language of information relating to a task should be clear for the audience, and the audience should be made aware of where this information can be found. (Task/instr. delivery)
8. Important objects should be salient and "pop out" from the rest of the environment. (Discerning importance)
9. Support thoughtful trial and error behavior. Do not irrevocably punish people for exploring the system. (Event triggering)
Taking Action
10. When possible, rely on control schemes that are intuitive or familiar to the audience. (Controller mapping)
11. Provide maps of environments to help guide players. Also, consider ways of quickly notifying players where they are through pop up descriptions or identifiable landmarks. (Spatial layout)
12. Summative challenges where players combine what they learned are valuable before entering the game. (Scaffolding)
Meaning Making
13. Tutorials/sandboxes are the best place to explore who or what affects change in the game. (Avatar schema)
14. Strive for consistency and provide as much information as possible in map icons. Provide a task where the player needs to find and understand the map early on. (Map schema)
15. When objects may appear ambiguous, provide references or characters where players can learn about objects. (Object schema)
16. Make few assumptions about the player and what they will understand. Provide training or reference materials for as many levels of play as possible. (Schema familiarity)
17. Do not allow players to initiate tasks unless the character can complete it. Use cues & affordances to reveal these roles. (Character role)

reviewing literature from HCI on heuristics, interpreting them into game terms, and finally verifying most of them through observation of game design practice. We feel that the contribution of this paper is to look specifically at game learnability. As such, this set of guidelines can be used to heuristically evaluate a game's learnability alongside the evaluation of its interface, mechanics, play, fun, and usability from these studies.

Finally, for this paper, we have concluded this study at the generation of this framework of guidelines. We leave the actual implementation and analysis of this framework in game design practice for future research.

CONCLUSION

In this study, we analyzed the process of embodied learning by observing the phenomenon of breakdown in players' use of video games. This experience has provided key insights and a framework for heuristically evaluating video games. Much of what games do already is very effective for building engaging and enjoyable experiences for a variety of players (see [11; 14] for a complete list), but this study has been about hooking new players into the fun of games.

This study of embodied learning has shown that there is a delicacy of immersion when considering the learnability of a game design. We want to provide situations that are immersive such that we prevent *breakdowns of illusion*, but we need to provide opportunities for *breakdown of interaction* to give players an opportunity to generalize from their experience. We believe that understanding learnability is crucial for achieving this balance in the design of games to ensure that player's experiences of a game are not pre-maturely curtailed. We feel that this set of guidelines provides a heuristic against which games can be analyzed so that designers can ensure that challenges designed into the game do not exceed the player's ability to overcome them and do not exceed the player's tolerance for *breakdown*.

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REFERENCES

1. Bayliss, P. (2007). Notes towards a sense of embodied gameplay. In *Proc. DiGRA 2007*. Tokyo, 96-102.
2. Barsalou, L. W., Breazeal, C., & Smith, L. B. (2007). Cognition as coordinated non-cognition. *Cognitive Processing, 8*(2), 79-91.
3. Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*, 32-42.
4. Choi, J., & Sato, K. (2008). Interaction as learning process: Incorporating domain knowledge into system

use. In *Proceedings of 5th NordiCHI*. Lund, Sweden, 73-82.

5. Clark, A. (1998). Embodiment and the philosophy of mind. In A. O'Hear (Ed.), *Current Issues in Philosophy of Mind: Royal Institute of Philosophy Supplement 43* (pp. 35-52). Cambridge: Cambridge University Press.
6. Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. New York: Harper and Row.
7. Dennett, D. (2003). Who's on First? Heterophenomenology Explained. *Consciousness Studies, 10*, (9-10), 19-30.
8. Desurvire, H., Caplan, M., & Toth, J. A. (2004). Using heuristics to evaluate the playability of games. In *Proc. CHI 2004*, Vienna, 1509-1512.
9. Doubleday, A., Ryan, M., Springett, M., & Sutcliffe, A. (1997). A comparison of usability techniques for evaluating design. In *Proc. DIS '97*, Amsterdam, 101-110.
10. Dourish, P. (2004). *Where the Action Is. The Foundations of Embodied Interaction*. Cambridge: MIT Press.
11. Dyck, J. Pinelle, D., Brown, B., & Gutwin, C. (2003). Learning from games: HCI design innovations in entertainment software, In *Proc. Graphics Interface 2003*, Halifax.
12. Federoff, M. (2002). Heuristics and Usability guidelines for the creation and evaluation of fun in video games. Unpublished thesis, Indiana Univ. < http://melissafederoff.com/heuristics_usability_games.pdf>
13. Fetterman, D. M. (1998). *Ethnography: Step by Step*. Thousand Oaks, CA: Sage.
14. Gee, J. (2003). *What Video Games Have to Teach Us About Learning and Literacy*. New York: Palgrave/Macmillan.
15. Hayles, N. K. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press.
16. Heidegger, M. (1962). *Being and Time*. New York: Harper and Row.
17. Jørgensen, A. H. (2004). Marrying HCI/usability and computer games. In *Proc. 3rd NordiCHI*. Tampere, Finland, 393-396.
18. Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.
19. Marsh, T., Wright, P., & Smith, S. (2001). Evaluation for the Design of Experience in Virtual Environments: Modeling Breakdown of Interaction and Illusion. *CyberPsychology & Behavior, 4*(2), 225-238.
20. McCarthy, J. & Wright, P. (2004). *Technology as Experience*. Cambridge: MIT Press.
21. Nielsen, J. & Phillips, V. L.. (1993). Estimating the relative usability of two interfaces, heuristic, formal, and empirical methods compared. In *Proc. InterCHI '93*, Amsterdam, 214-221.
22. Pagulayan, R. J., Steury, K. R., Fulton, B., Romero, R. L. (2003). Designing for fun: User-testing case studies. In M. A. Blythe, A. F. Monk, K. Overbeeke, & P. C. Wright (Eds.), *Funology: From Usability to Enjoyment*. Dordrecht: Kluwer Academic Publishers.
23. Reeves, S., Brown, B.. & Laurier, E. (2009). Experts at play: Understanding skilled expertise. *Games and Culture, 4*(3), 205-227.
24. Scaife, M., & Rogers, Y. (1996). External cognition: How do graphical representations work? *Int. Jour. Human-Computer Studies, 45*, 185-213.
25. Sherry, J. L. (2004). Flow and Media Enjoyment. *Communication Theory, 14*(4), 328-347.
26. Shneiderman, B. (1983). Direct manipulation: A step beyond programming languages. *IEEE Computer, 16*(8), 57-69.
27. Suchman, L. A. (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge: Cambridge University Press.
28. Urquijo, S. P., Scrivener, S.A.R., & Palmén, H. K. (1993). The user of breakdown analysis in synchronous CSCW System Design. In *Proc. ECSCW 1993*, Milan, Italy, 281-293.
29. Varela, F. J., Thompson, E., & Rosch., E. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: MIT Press.
30. Winograd, T., & Flores, F. (1986). *Understanding Computers and Cognition: A New Foundation for Design*. Norwood, NJ: Ablex.
31. Zagal, J. P., & Bruckman, A. S. (2007). Gamelog: Fostering reflective gameplay for learning. In *Proc. Sandbox Symp. 2007*, San Diego, 31-38.