Embodied learning in video games: A framework and methodology for evaluating interactive entertainment

Abstract
This paper describes using breakdown [24] in players’ use of video games to analyze the learnability of these games. This paper emphasizes the importance of two levels of breakdown that support (breakdown of interaction) and break immersion (breakdown of illusion) in games respectively [17]. I conducted a study to investigate learning in games. From this study, I constructed a framework of nineteen patterns of breakdown for the evaluation and design of video games and for insight into human-computer interaction. This framework helps designers support breakdown of interactions so that they do not become breakdowns of illusion.

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

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.
Introduction

For researchers in interaction design, games along with many other forms of interactive entertainment become unique challenges to design because the tasks in the game must be non-transparent and non-obvious to the player. At the heart of the experience of gameplay is an inherent challenge that players must grapple with to play the game. This paper uses the perspective of embodied interaction [7] to analyze this phenomenon and stresses the importance of learnability to support immersion and fun in video games. I believe that parallels can be drawn from these findings to the design of interactive software as a whole. For all interfaces that we design, considerations for learning curves must be considered [8, 16, 20]. Even if we include affordances that make interaction intuitive or metaphors that are perfectly understandable to the user, the users must ultimately learn what to expect from the software application, what it enables them to do, and what its limitations are. Oftentimes, users cannot know this until they sit down and use it. Users will attempt to understand and use the software in terms of their prior understanding, which is a part of their domain of embodied experience. Users can adapt to any software design for their needs despite how poorly it was designed for them, but designers must give them the proper resources and motivation.

For instance, consider everything that players must learn when they play the game Tetris. There are meanings in the relationships between blocks placed in the space, the rules about how they can place the blocks and how they win, and mappings between buttons they press and the change in the game. When players have deeper embodied experiences with this game, they get closer to understanding the rules that support the underlying interaction and can play this game more effectively and have an enjoyable experience. At the same time, this deep understanding of underlying rules expands their domain of experience altering the domain of interactive devices that they will be able to easily interact with and even altering their perceptions of interactivity.

In this paper, I explore the phenomena of embodied learning in video games. The first section describes the theoretical sources that support these concepts. The following section describes the concept of breakdown in more detail, its relation to immersion, and how it can be used to analyze a player’s experience of a game. The fourth section describes a study that was conducted to observe players of varying levels of experience play games that they are unfamiliar with. The fifth section describes a framework that organizes patterns of breakdown that were observed from the study. The paper ends with an explanation of what game and HCI designers can take from this study.

Theoretical Background

There are several terms used throughout this paper that are shaping this research: embodiment, domain of experience, and breakdown. I will provide my interpretation of what these terms mean and how I use them in this paper as well as how they are used from an HCI perspective. These terms help me to summarize the theoretical foundations that this paper comes from (see figure 1 for a graphical summarization).

Embodiment

The term embodiment is central to the perspective of the paper. The embodied perspective focuses on the
interrelation of cognition and action [1, 4]. I use *embodiment* to describe a shift in the notion of interaction from separately analyzing the device and user towards an integrated analysis of both in interaction with each other. Consequently, the user’s interactions with the external environment are fundamental to understanding their cognitive processing of external representations [5, 20]. Dourish [7] described the phenomenon of *embodied interaction* through the participative nature of interaction. He emphasizes the importance of the environment of a system as it shapes the meaning of a given interaction through participation in that environment/world including the social and tangible.

The environment also shapes the actions that we can take by providing affordances for action [9, 11, 18]. The notion of affordance comes from ecological psychology where the environment in which one is situated becomes essential for vision and action. As designers, we rely on affordances to guide users along through their use of an interactive artifact and even interact with other users [3]. Given the complexities of games and other entertainment artifacts, it is these affordances which will alter users’ perceptions and encourage certain actions in the environment.

*Domain of Experience*

Affordances in an environment account for some guidance of user action. However, there are some situations where no amount of affordances can help a person that lacks experience in a certain task. We must also account for the experience of the individual to understand the interaction and to really grasp its learnability. We can understand this prior knowledge in terms of *domains*. Gee [10] explains that knowledge and experience form around *domains* in which an individual can *act upon* that knowledge. These *domains of experience* help to give meaning to the knowledge that we wish to apply and the actions we take in a given situation. It provides the context for a given individual for these actions.

From a situated action perspective, the use of a device always shapes the perception of those devices and the space of what is possible using them [2, 23]. 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 similar phenomena (as in Hayles’s [12] inscribed and incorporating practices or Shneiderman’s [22] syntactic and semantic knowledge). The domain of *embodied knowledge* allows us to change our understanding about the present as well as the past and future such that we alter our expectations of what is to come [14].

**Breakdown**

Phenomenology has had a strong influence on my study, especially the work of Martin Heidegger. Heidegger [13] 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 with the device and not consciously on the device itself. In a sense, the device becomes an extension of the user. When they experience it as present-to-hand, however, they focus specifically on the device, which has gone from being an extension to
being an impedance, as they try to resolve the problem.

The cause of this transition from ready-at-hand to present-to-hand is called breakdown [24]. Breakdown could be described as a separation of the user’s domain of experience and the domain in which an interactive device normally operates (figure 1). This can occur when a device operates in a way that the user is unfamiliar with, or when the user uses a tool in a way that is outside of its normal domain. For instance, the Apple application iMovie was designed for making very simple movies and helping users easily make DVDs. However, as soon as a user (myself) wants to make something more complicated, iMovie makes the process much more difficult than it needs to be and occasionally crashes. In game terms, we can consider how an increase in the difficulty of the game forces us to change our strategy, which can be as fundamental as how we hold the controller (a guitar) in a game like Guitar Hero when we are forced to play all five notes using only four fingers (see figure 2).

When breakdown occurs, we can either stop or change strategies. When changing strategies, we are supported by training and tutorials, playful exploration of the environment, and social guidance (figure 1). Training is a part of the design of many interactive artifacts, 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 [4, 20]. 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 I will analyze players’ use of video games.

An Alternative Model for Evaluation of Interactive Entertainment
While games can benefit from a certain amount of usability [15, 19], the challenges of play are an inherent part of all well-designed games. A completely transparent game will not provide an adequate user experience. Csikszentmihalyi [6] explains that challenges of an activity must be balanced with the skills of the player towards that activity to experience flow, which is a state very similar to immersion (see figure 3). Sherry [21] extended this notion to video games to show how those skills rely on a literacy that develops in parallel with this state of flow. I see this literacy as similar to a domain of experience. By overcoming these obstacles and developing an ever increasing embodied experience of the game world, players benefit psychologically from completing game objectives.

There are two levels at which breakdown can occur from these states of flow mentioned by Marsh et al. [17] in describing the continuity of illusion in virtual environments. The first level is when breakdown is just part of the task and that overcoming the challenge enhances the player’s experience. They describe this as breakdown in user’s interaction, which happens at the level of changing conditions and forces players to develop new strategies. The second level is when players become so disconnected with the game not functioning as expected that they are completely thrust out of the state of flow. This is described as breakdown in illusion, which happens when players lose focus of the virtual environment they are using. This framework allows Marsh et al. [17] to organize common problems to identify the most likely cause of these breakdowns.
I wish to propose an alternative framework for guiding the design of interactive entertainment, video games, and learning experiences using technology. This framework is to evaluate aspects of an environment that under certain conditions can lead to breakdown of interaction, so that we can potentially avoid issues of breakdown in illusion. For instance, let us assume that we have a game where to get to the next section players need to open a door that is locked. Convention dictates that they need to find the right key for that door. An experienced player would cycle through the following activities to try to find this key: previous items collected in their inventory, nearby characters in the game that they can talk to, nearby treasure chests, previously unfinished quests, and so forth. For an inexperienced player, there is a lot that is being assumed about what they are going to figure out to do next. The proposed framework would expose assumptions such as these to improve the design of software for all types of users.

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 is a question both of varying abilities of players and in the types of obstacles that players face. The purpose of this study was to put players of varying abilities in situations that they are at least initially unfamiliar with to encourage breakdown to occur.

Participants
Participants for this study were included from members of the School of Informatics community at Indiana University. I had personal relationships with all the participants in the study. I felt that this was a strength of my research design rather than a weakness as I relied on an intimate conversation with participants about their experience. Thirteen participants helped in the study (eight male, five female). Also, there was an even split in self-reported previous level of video game experience (see figure 4).

Study Design and Methods
Each session took approximately three hours. The study began with an initial interview that was used to gauge the person’s experience with various types of games. I asked participants questions such as:

- How often they played video games.
- What games have they played in different genres of video games.
- What would they rate their experience with video games and computer technology in general on a scale from 1-10.

Based on this interview, one to two video games were selected for participants to play, which I assigned based on what they had the least amount of experience with. While playing the games, I asked participants to talk aloud about their experiences, and asked questions about their experience. For the study, I needed both to be very experienced with the game to understand designer’s expectations of players in and to ask naïve questions to the players to understand their experience. Through this deeply interpretive study, I wanted to see these patterns of expectations of both players and designers and where they did not line up.

I identified breakdown both verbally by participants’ report and through subtle non-conscious indicators including expressions of surprise (e.g., “What?” and

![Figure 4. Histogram of the frequencies of participants reporting their previous video game playing experience (ability).](image)
“Ohhhh!”), behavior changes from game feedback, particularly erratic or wandering, and trial and error behavior in trying to accomplish a task by incrementally altering strategy. Furthermore, breakdown manifested itself in the players’ gameplay through frustration due to confusion in the task and accidental discoveries of affordances. Frustration occurred when the player could not figure out how to accomplish a task, while accidental discoveries occurred when the player learns something new unexpectedly.

I concluded each study session with a debriefing section to give the participants an opportunity to talk about their strategies used in the game [23].

Patterns of Breakdown

Nineteen patterns of breakdown emerged through the play that each of the participants to varying degrees needed to contend with. These patterns were grouped into five organizational categories: instructions, cues and hints, player algorithm, player action, and meaning development (see figure 5).

Instructions Category

The category of instructions included patterns related to what the game explicitly tells the player or what is revealed through gameplay. The first pattern is instruction order, which typically occurred when the timing of an instruction failed to meet what the player expected. For designers, this is particularly difficult because many games can be played in a variety of different orders. An example of this in the study was when a participant playing the game *Gladius* was waiting for a level to load, and the computer gave a tip about a multiplayer feature in the game that he did not even have access to yet causing the player confusion whether the next task was multiplayer. Another pattern is instruction delivery, which involved breakdowns of how instructions were stated to the player. An example of a breakdown in instruction delivery is in the game *Sly Cooper 2*. The participant in this study was given the instruction in figure 6. While the participant had “jumped” before this early point in the game, it was never formally mapped to any buttons on the controller making 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.

Another pattern deals with tutorial scaffolding. Tutorial scaffolding involved integrating elements to a game to make it more complex than the early levels so that
strategies that were used earlier must be synthesized together. The game Katamari Damacy handles this breakdown well (see figure 7), as players roll a Katamari ball around a 3D environment and collect objects in the environment up relative to the ball’s size, which increases as the game goes on. This game provides a natural transition between early and later stages allowing breakdowns to happen, but keeping the players immersed. Finally, cognitive overload occurs as the number of elements that a player must attend to in the instructions increased. Typically players will just ignore the excess information even if it is valuable. Games like Civilization IV with their rich interfaces are a good example of this pattern where players who are experienced with this interface can gain a lot of information from it, while players with little experience become overwhelmed.

Cues and Hints Category
The cues and hints category dealt with how the game used affordances, and how the game guided players. Object cues are affordances and feedback that a player received from objects to give them indications of the way in which they could interact with these objects. Katamari Damacy (figure 7) is an example of this breakdown when players receive feedback from objects they roll over. If the objects are too big to fit into the Katamari, the Katamari will bounce off the object with a crashing. Cursor cue breakdowns are similar to object cues, but occurred when the cursor changes in response to a player hovering over objects in the environment. Myst V changed its hand cursor based on an object that a player could interact with (e.g., hovering over a lever changed the flat hand cursor to a grasping hand cursor). The last pattern in this category is cut scene transitions. These breakdowns are subtle, but occurred when a player transitioned from passively watching a cut scene movie to actively playing in the game. When the cut scenes looked identical to the action in the game, it took a moment for the player to realize that they now controlled the character such as in Metal Gear Solid, Final Fantasy XI, and Fable where the game engines themselves are used for cut scenes.

Player Algorithm Category
The player algorithm category includes breakdowns that occurred as the player tried to figure out what to do in the game. The first pattern is breakdowns in distinguishing importance. These occurred when a player needed to evaluate what features in a game were important to the current action and what could be ignored. In the game SSX, players needed to snowboard or ski down a mountain while avoiding obstacles in the path. In certain instances, though obstacles or scenery such as railings or fallen trees could act as shortcuts giving the player an advantage in the race transforming the play experience (see figure 8). Causal Association breakdowns occur as a player needed to predict what would occur in the game when a certain action was taken. One participant struggled because of this in Age of Empires in an attempt to manage different types of units for specific tasks. Event triggering, the last pattern in this category, is similar to causal associations except that, given a player goal, it required the player to choose what action to take to make that action happen. Examples of this are opening doors and speaking with various characters in NeverWinter Nights and Morrowind.

Player Action Category
The fourth category of player action organizes patterns of breakdown that occurred when a player tried to
The pattern of controller use required the player to consider how the buttons that they pushed or the gestures they made effected change in the 3D space. This is a problem that must be addressed universally by all games, but is especially important for games that have no precedent for controller use such as Guitar Hero whose controller naturally mimics a guitar. Another pattern in this category is understanding space. This dealt with how players constructed a mental map of the environment to remember how the environment was arranged. A particular instance of this problem in the study was in the game Indigo Prophecy. The participant had about one minute to navigate his character's apartment to perform several small tasks to hide evidence against his character before police entered the apartment. It took the participant many tries before he developed a strategy that worked relying on knowledge of the apartment. Camera and navigation is a pattern of breakdown that dealt with how the player needed to control both what the camera looked at as well as how the player's character moved. This issue is something that must be negotiated in games like Halo or CounterStrike where the camera and navigation are controlled using separate controls. The last breakdown in this category is depth perception. This breakdown occurred in 3D spaces where players needed to reconstruct the depth of space through motion [11] because of the 2D projection of the game.

Meaning Development Category
The category of meaning development included breakdowns that involved representational issues in the game that the player needed to resolve to play. The first breakdown pattern was in-game representation, which occurred when players needed to resolve what a game object meant. A simple example is that bouncing Lego pieces in Lego Star Wars means that you can build something using these pieces (see figure 9). These breakdowns often have to do with the metaphor that is used for an interactive object. The next pattern, character role, dealt with breakdowns in players' understandings of the abilities of each character or unit that players controlled. This can occur in a game where the player controls a single player with different sets of abilities such as Kameo, multiple characters with different abilities such as Final Fantasy X, or multiple specialized units distinguished by roles such as Age of Empires. The third pattern in this category is breakdowns in map representation. This occurred when a player needed to relate a mini-map representation with how it related to the 3D environment as a whole. A participant playing Grand Theft Auto found that once they were able to internalize the mini-map of the game, they were able to navigate in it much better.

The fourth pattern of breakdown in meaning development is assumed conventions. Game developers make many assumptions about the type of player that is playing games they design, which is not unreasonable, but it can close off the game to wider audiences. The tutorial in Civilization IV was effective for transitioning players from previous versions of the Civilization series, but it closed itself off from new players because the tutorial would simply point out the differences between this version and prior Civilization games, but did not explain well the basic operations of the game itself. Another example is in Sims 2 where a 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 need sun, which the game itself did not
require. This instance shows that when unspecified, players will bring their own conventions in from the outside world. The final pattern of breakdown is avatar representation. Each game represents who the player is in the game space differently. This includes the figureless rotator in Tetris, the single deific hand in Black & White, the multiple-unit manager in Age of Empires, the third person perspective avatar of Tomb Raider, or the first person perspective avatar of Halo. Each of these perspectives changes the experience of the player in ways that they must become accustomed to.

Conclusion
In this study, I analyzed the emergence of breakdown in the interaction between players and video games. This experience has provided key insights for the evaluation and design of video games. Furthermore, I believe the issues addressed in this paper are applicable to the field of HCI more broadly.

From the standpoint of the evaluation of games, I believe that understanding learnability is crucial for finding balance in the design of games. Video games are activities based on the acquisition of skills. I believe Nintendo has realized this in the design of the Wii in their mission to open a wider audience to console video games. By developing a system that is not only easy to use, but also inviting in its familiar metaphors (e.g., Wii-mote), the Wii has so far been successful in this mission. I feel that this framework would be useful for evaluating the design of games to understand the learning curve and learning process of a game between a variety of audiences.

From the standpoint of the design of games, this study has provided several key insights. First, designers must carefully think about the metaphors of game interaction. A poorly thought out way of interacting with the 3D space can become an impediment itself. Designers must consider not only the best way of interacting in a game, but also what is easiest to learn. Secondly, 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 [17], but we need to provide opportunities for breakdown of interaction to give players an opportunity to generalize from their experience. Third, designers must think about the ways in which a player can playfully explore the environment. The game must support a player’s ability to experiment with the environment and explore the space of possibilities that is opened up by it. Even games that are tied to a linear narrative such as Final Fantasy X allow exploration through different aspects of the system such as skill development. Finally, designers must consider the balance between challenge and usability as crucial to that game’s success.

Finally, I also believe that the study provides insights for the HCI community. I feel this study highlights the notion of an interface as opening up a perceptual and embodied space. There is a depth that is possible in our interaction with technology that we often subconsciously enter into as we are immersed in our actions. Consequently, I feel the framework constructed from this study can apply more broadly as well.

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References


