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Game-play breakdowns and breakthroughs: Exploring the relationship between action, understanding and involvement

Ioanna Iacovides[1], Anna L. Cox[1], Patrick McAndrew[2], James Aczel[2], and Eileen Scanlon[2]

[1]University College London, United Kingdom

[2]Institute of Technology, The Open University, United Kingdom

Running Head: Game-play breakdowns and breakthroughs

ABSTRACT

Game developers have to ensure their games are appealing to, and playable by, a range of people. However, while there has been interest in the game-play experience, we know little about how learning relates to player involvement. This is despite challenge being an integral part of game play, providing players with potential opportunities to learn. This paper reports on a multiple case-study approach that explored how learning and involvement come together in practice. Participants consisted of a mix of gamers and casual players. Data included interviews, multiple observations of game-play, post-play cued interviews and diary entries. A set of theoretical claims representing suggested relationships between involvement and learning were developed on the basis of previous literature; these were then assessed through a critical examination of the data set. The resulting theory is presented as 14 refined claims that relate to: *micro and macro involvement*; *breakdowns and breakthroughs in action, understanding and involvement*; *progress*; and *agency, meaning and compelling game-play*. The claims emphasize how players experience learning via breakthroughs in understanding, where involvement is increased when the player feels responsible for progress. Supporting the relationship between learning and involvement is important for ensuring the success of commercial and educational games.

CONTENTS

1. INTRODUCTION

Video games are part of mainstream entertainment with revenues rivalling the film industry. For instance, *Call of Duty: Black Ops 2* broke records in 2012 by grossing over $500 million within 24 hours of its release (Waterman, 2012). Innovative motion controllers, such as the Nintendo Wiimote and Microsoft Kinect, and the introduction of social network and mobile games have helped games reach a wider audience than ever before (Juul, 2010). For example, *Candy Crush Saga* declared 93 million active users each day as part of the share offering of its developer (SEC, 2014). However, it is not always clear why some games achieve this level of success and other do not; up to 80% of titles fail commercially (Hollins & Whitton, 2011). Success can be even harder to achieve for mobile and independent games, in a market where 60,000 apps are released each month on the Apple store alone (adjust, 2014).

Along with the rising popularity of games, there has been an increasing research focus on what makes game-play so involving (e.g. Sweetser & Wyeth, 2005), how to evaluate the player experience (e.g. Mandryk, 2008) and how games can be used for educational purposes (e.g. Harpstead, Myers & Aleven, 2013). Interest in the Game User Experience (GUX) includes the optimal experiences of involvement, such as game flow (Sweetster & Wyeth, 2005), and the more prosaic experience of being engaged in game-play, such as the Core Elements of the Gaming Experience (Calvillo-Gamez, Cairns & Cox, 2010). Much of this research agrees that challenge is an important game-play component (Cox, Cairns, Shah & Caroll, 2012). A challenge also offers an opportunity to learn and therefore, as some designers have argued, learning is an integral part of game-play (Koster, 2005). However, the nature of the relationship between learning and involvement, often implied in game-based learning research, has rarely been investigated explicitly. GUX research also tends to focus on specific instances of play, i.e. micro involvement, rather than longer-term motivations and the activities that occur around play, i.e. macro involvement. Indeed the relationship between these two levels of involvements and learning is also not clear.

One consideration of learning through games is how experiencing a breakdown during play may lead to learning (Pelletier & Oliver, 2006). Building on this and other work we use a multiple case-study approach (Yin, 2009) to present a theory of how involvement and learning come together in practice within the context of gaming. The data collection methods are discussed in Iacovides, Aczel, Scanlon & Woods (2013) and the categorisation of breakdowns and breakthrough introduced in Iacovides, Aczel, Scanlon and Woods (2011). Here we focus on the main analysis and findings to demonstrate that whilst some breakdowns are catastrophic and lead to disengagement from the game, others lead to progress (via action breakthroughs) and learning (via understanding breakthroughs). We also explore how macro level activities relate to micro level involvement and learning. The findings relate to the design of both commercial and educational games.

1.1. The game user experience (GUX)

In the field of HCI there has been increasing attention towards affective issues and evaluating the wider user experience. While some HCI researchers focus on the general structure of positive experiences and the elements that support them (e.g. (e.g. Hassenzahl, 2008) others take a broader focus. For instance, Wright, McCarthy and Meekson (2003) argue: "Rather than isolate the elements of experience we seek to understand their interaction and how they mutually constitute each other. We also seek a stronger account of sense-making as the central process of experiencing." (pp. 43-44). Research investigating the Game User Experience (GUX) tends to adopt the former approach rather than the latter with the focus on investigating specific instances of play in order to establish how involved a player is in the game. Brown and Cairns (2004) describe involvement as a graded experience that ranges from simple engagement with a game to total immersion, where immersion refers to the sense of being cognitively involved in a game to the exclusion of the outside world (Jennett et al., 2008).

As an example of research that has focused on extreme forms of involvement, Sweetser and Wyeth (2005) present a model of Gameflow that was inspired by the concept of "flow" (Csikszentmihalyi, 1990). Flow occurs when there is a balance between someone's skills and the challenge presented to them with the result that they become so engaged in the task at hand that their attention is focused, they feel more in control, they do not feel self-conscious and nor do they realise how much time has passed. For Gameflow to occur, a game needs to support player concentration; provide a challenge that matches player skills level; support the development of player skills and mastery; allow the player a sense of control; provide clear goals; provide appropriate feedback; and support the experience of immersion. Sweetser and Wyeth (ibid) also suggest that social interaction can make games enjoyable but that it is not necessary for game flow. While this model of Gameflow highlights the importance of challenge and skill level within game-play, the focus is on game elements which support optimal involvement rather than on the experience of involvement itself (Cairns, Cox & Nordin, 2014). The relationship between Gameflow and immersion is also unclear; players are either in flow or they are not, but they can feel immersed to different degrees. Other work (Cox, Cairns, Shah & Caroll, 2012) has shown that challenge acts in combination with expertise to influence the graded experience of immersion. Essentially, those with more experience were found to be more immersed at higher levels of challenge while those with less experience were more immersed at lower levels of challenge.

Instead of focusing on extreme forms of involvement, Calvillo-Gamez, Cairns and Cox (2010) focus on the more prosaic experience of engagement in order to elicit the Core Elements of the Gaming Experience (CEGE). The CEGE were identified as: *control*, *ownership* and *facilitators*. Control depends on the player learning to manipulate the game and the controllers; ownership refers to the player taking responsibility for their actions which the game rewards him or her for; and facilitators are subjective elements that relate to external factors such as previous experience and aesthetic values. However, while challenge and control have also been identified as important elements of the game-play experience in other research (Malone, 1981; Malone & Lepper 1987; Lazzaro, 2004; Cairns, Cox & Nordin, 2014), their relationship to learning has rarely been considered beyond the scope of the initial game controls and mechanics. This is despite the fact that

challenges, in the form of breakdowns and game impasses, offer players an opportunity to learn and learning has been argued to be an integral part of game-play (Koster, 2005; Gee 2007).

1.2. Breakdowns and breakthroughs

In research which considered how learning occurs during game-play (though not necessarily in relationship to involvement), Pelletier and Oliver (2006) present a method for analysing games which draws upon a refinement of Activity Theory (Kuutti, 1996). Their method involved decomposing player activities into actions and operations, and noting contradictions (i.e. breakdowns and problems) that occur. Pelletier and Oliver (ibid) were specifically concerned with exploring how contradictions influence learning within instances of observed play. The decision to focus on "problematic or 'contradictory' moments" as sources of learning provided a focus for analysis and resulted in a set of rules based on proposed explanations of player behaviour e.g. "spot unusual objects and click on them" (p. 335). The authors conclude that the method was useful for establishing how players develop strategies and helped establish how players learn to play. However, while the detailed analyses allowed them to document the learning that occurred, they needed to make inferences about the reasons behind the operations carried out. As such, it is not clear how far the inferences made actually motivated player behaviour.

Barr (2007) acknowledges the contribution of Pelletier and Oliver (2006) in terms to using Activity Theory to analyse gameplay, though he makes a further distinction between breakdowns and contradictions. Barr suggests a breakdown occurs when the general flow of an activity is interrupted e.g. a player pressing a button by mistake causing their avatar to jump instead of duck. While these disruptions are a common part of gameplay (and usually overcome quickly), Barr argues that repeated breakdowns within an activity are likely to indicate "systemic breakdowns" which reflect "underlying contradictions" (p. 160) within an activity system (e.g. repeatedly pressing the wrong button can indicate poor design). However, Barr was not explicitly concerned about the relationship between learning and involvement. Through adopting a multiple case-study approach, his main goal was to consider the concept of video game values, e.g. play and progress, and how they are expressed during play via the game interface (Barr, Noble, Biddle & Khaled, 2006).

Ryan and Siegel (2009) also used the concept of breakdowns to consider how a player goes about learning to play within the game. In this case, breakdowns are generally described as occurring "when actions we take to accomplish something no longer seems [sic] to work" (p.1). Drawing upon the work of Marsh et al. (2001), Ryan and Sigel consider both learning and involvement when they make a distinction between interaction and illusion breakdowns. A breakdown in interaction refers to what they describe as "the natural breakdowns" that lead to learning within the game while a breakdown in illusion refers to a loss of "immersion" (in terms of absorbed attention). Ryan and Siegel argue that the former are part of normal game-play, but unlike the latter, they do not disrupt the experience of flow (i.e. extreme involvement). As a result of their analysis, they present four main categories of breakdown relating to: perceiving the environment, developing strategy, taking action, and meaning making. However, while it is seems implied that

most breakdowns stem from interaction issues and some can lead to further breakdowns in illusion, it is not clear why some breakdowns end up affecting involvement and others do not.

In a study examining the role of failure within game play there is some evidence to suggest "the idea that growth, the experience of learning, of adjusting strategies, of trying something new, is a core attraction of video games" (p. 11; Juul, 2009) as it can make the game-play experience more complex. However, less consideration has been given to how breakdowns are actually overcome. Aarseth (1999) discusses the dialectical relationship between "aporia" and "epiphany" within games, where the term aporia refers to the "localizable 'roadblocks' that must be overcome by some unknown combination of actions", and epiphany is described as "a sudden, often unexpected solution to the impasse in the event space" (p. 38). However, Aarseth is concerned with the non-trivial effort required by game-play, rather than the learning involved in overcoming challenges and how this process relates to player involvement.

Sharples and colleagues (Sharples, 2009; Vavoula and Sharples, 2009) also consider breakdowns and when they are overcome within the context of gathering mobile technology design requirements for educational purposes. Sharples (2009) defines breakdowns as "observable critical incidents where a learner is struggling with the technology, asking for help, or appears to be labouring under a clear misunderstanding" while breakthroughs are "observable critical incidents which appear to be initiating productive, new forms of learning or important conceptual change" (p. 10). Vavoula and Sharples (2009) distinguish between the micro, meso and macro-levels, which relate to usability, learning and wider organisational issues respectively (and where breakthroughs only seem to occur in terms of learning on the meso level).

The literature indicates that failure is a common part of game-play, where some breakdowns can lead to learning and others can influence involvement. However, it is not clear why these different breakdowns occur or what the relationship is between them. Further, the process by which they are overcome has rarely been considered. The concept of breakthroughs could also be useful for examining learning in the context of game-play.

1.3. Macro level involvement

Research on evaluating the GUX and understanding breakdowns has primarily focused on sessions of game-play. This micro level experience represents only part of player involvement. Calleja (2011) presents the Player Involvement Model (PIM), considering both micro and macro involvement. The micro level relates to "the moment-by-moment engagement of gameplay", while the macro level relates to "longer term motivations as well as off-line thinking and activities that keep players returning to the game", covering both "postgame and pregame experiences" (ibid; p. 40). The PIM highlights the importance of what happens during play and what happens around it e.g. talking to friends and looking up external resources. Consalvo (2007) defines external resources as paratexts, with games themselves considered to be the primary texts, and examples of paratexts include game-related walkthroughs, previews, YouTube videos, blogs, reviews, magazines etc. Player involvement is thus likely to be influenced by exposure to different forms of paratext.

The PIM is a descriptive framework that allows for qualitative considerations of micro and macro involvement across six dimensions: kinaesthetic, spatial, shared, narrative, affective and ludic. When the player internalises each of the relevant dimensions, it can result in an extreme form of involvement Calleja (ibid) calls "incorporation": "a synthesis of movement (kinaesthetic involvement), within a habitable domain (spatial involvement) along with other agents (shared involvement), personal and designed narratives (narrative involvement), aesthetic effects (affective involvement) and the various rules and goals of the game itself (ludic involvement)" (p. 169-170). The model suggests a close relationship between involvement and learning, as deeper forms of involvement can only be experienced through successful internalisation, i.e. through a process of learning (Iacovides, 2009). The PIM thus supports those who argue that learning and playing are synonymous components of game-play (Koster, 2005; Gee, 2007). However, the relationships between different forms of involvement and learning are not made explicit in the PIM, nor does the framework indicate how learning can be examined.

1.4. Research aim

Aspects of both micro and macro player involvement have been investigated but there has been little consideration of how the two relate to each other. Further, while there has been some consideration in the literature of breakdowns that occur in relation to learning and involvement, the relationship between them has not been explicitly investigated. This is despite the fact that challenge has been noted as an integral part of game-play and, through a process of overcoming it, provides opportunities for learning. This article considers the relationship between micro and macro level involvement and investigates what breakdowns and breakthroughs can tell us about how learning and involvement come together in practice. In order to explore these relationships we present a multiple case-study approach and an initial set of 7 claims which were extracted from the literature after a preliminary analysis of the data. The initial claims represent suggested relationships between macro involvement, micro involvement and learning. In the main analyses, the claims are evaluated against an examination of the case-study data set and presented as a set of 14 refined claims relating to: *micro and macro involvement*; *breakdowns and breakthroughs in action, understanding and involvement*; *progress*; and *agency, meaning and compelling game-play*.

2. METHOD

2.1. Participants

Nine participants (5 Male; 4 Female) took part (mean age: 33.2yrs; age range: 23-59). Players were recruited from a previous email interview study we conducted to investigate the gaming experiences of casual players and more dedicated gamers (Iacovides, 2012). Participants differed in terms of age, gender, and how they identified as gamers (5 explicitly identified as gamers, 4 did not).

2.2. Design

Yin (2009) argues that through collecting multiple sources of data, building explanations and comparing across cases validity is increased while reliability can be ensured by following a case-study protocol. Further, the examination of several cases enables

"insight into an issue or refinement of theory" (p. 88, Stake, 1998). We therefore adopted a multiple case-study approach involving a mix of methods and tracking participants over time in order to capture micro involvement, macro involvement and learning. While multiple methods are often used in HCI, case-study approaches are less common. An exception to this is work by Barr and colleagues (Barr, Noble, Biddle & Khaled, 2006; Barr 2007) who adopted a collective case-study approach (examining 5 games, played by 5 people). Game-play was analyzed by focusing on contradictions and breakdowns, while grounded theory was used to uncover the values expressed during play.

The aim with a case-study approach is not to make statistical generalisations about frequencies and populations but to make analytical generalisations that expand theories (Yin, 2009). By maximising the differences between cases as far as possible, as recommended by Stake (1993) we follow Barr (2007) who argues that multiple cases "shed light on one another and to contribute to a more generalisable resulting theory." (p. 44). The recruited participants differed in terms of age, gender and gaming identity. One case consisted of two participants (a married couple) included in order to consider some of the social influences that might affect involvement and learning.

As part of our approach, multiple methods were adopted, including observation, post-play interview, the collection of physiological data, asking participants to keep gaming diaries over a three-week period and interviewing them at the end of the study using the diary entries as a prompt. A case-study protocol was also developed to ensure the researcher followed a similar procedure in each case. Unlike Barr (2007), grounded theory was not adopted for data analysis. Instead the analysis was influenced by Popperian ideas that emphasise the development of knowledge through theoretical and/or empirical testing (Aczel, 2006). Rigor involves subjecting claims about the world to testing through critically assessing the data available and recognising the potential limitations of resulting interpretations. Additionally, validity depends on the elimination of erroneous ideas as "although we can never know if we have found the truth, there is the potential to discover error" (p. 161; Aczel, 2006).

2.3. Procedure

Piloting with five individuals (age range: 24-33; 4 male, 1 female) across seven sessions took place to ensure that the lab and data collection was set up appropriately. These individuals were not involved in the main study.

The lab was set up as a relaxed living room environment, with adjustable lighting, a couch, wide screen TV and game consoles. In order to make the participants as comfortable as possible, an introductory session was included where they were introduced to the equipment and procedure for subsequent sessions (as suggested by Mandryk, 2008). Participants came in to play in the lab in three separate sessions.

In the first session a preliminary interview was carried out and the physiological equipment was explained. Participants filled in and discussed a short questionnaire about their gaming habits and preferences. A consent form asked whether there were any games they did not want to play. Participants also brought in a game of their choice to play for 15 minutes. During gameplay, the researcher observed the session from a separate room

which displayed camera feeds of the player and the game-play, as well as the player's physiological reactions on a laptop (see Figure 1). Game-play was recorded for reviewing with the participant their thoughts and feelings during play. Tea/coffee and biscuits were provided during the post-play interview, to encourage a relaxed experience.

<Figure 1 about here>

The second session took place a week later. The participant was again asked to bring in the games they were currently playing. This meant ensuring the player could continue their progress from the last time they played through either transferring a saved game file to their console of choice in the lab, or by bringing in their own console to play on. For the third session, the player was asked to play a game they had not played before, selected on the basis of the preliminary interview from a genre of game they were unlikely to pick themselves. The purpose of this was to examine what happened when they played something unfamiliar, although care was taken to make sure they had no objections to the researcher's choice. The main sessions followed the same format as the first, though participants were asked to play for longer (up to an hour). Overall, the session lasted from 2-3 hours.

Over the three week study period, participants were also required to keep a paper based gaming diary in order to keep track of game-play outside the lab and to gain insight into macro-level involvement. Elliot (1997) outlines the "diary interview" method as a way of observing behaviour that would otherwise be inaccessible. The diaries allowed further insight into the real-world contexts of gaming by asking players to take note of what they played every day and for how long; what they did when they got stuck; who they talked to about games; whether they visited or contributed to online gaming resources; and whether they thought they learnt anything from their activities. Participants were asked to fill in the diary daily, even if nothing game-related occurred, in order to develop the habit. Though still retrospective, Mackrill (2008) suggests that "diary data are generally recorded closer to the event than retrospective interviews or questionnaires. This is presumed to improve the accuracy of the data" (p. 12). Participants were asked to bring in diaries to each observation session to encourage completion. The case studies concluded with a final ½-1 hour semi-structured interview participant, reviewing their diary entries. This allowed for further discussion of the activities noted and enabled participants to reflect on their gaming experiences over the course of the study. Participants were given a £15 voucher to thank them for their participation.

3. FINDINGS

3.1. Introducing the cases

A questionnaire was adapted from Joiner et al., (2011) and completed during the first session, participants were also asked whether they would describe themselves as a gamer or not. Figure 2 illustrates the demographic information collected from the questionnaire relating to each of the participants (pseudonyms are used) who took part. [See supplementary materials for further information about the participants].

<Figure 2 about here>

In all cases (apart from case 8 which consisted of two participants), single-player games were used or the single-player mode was selected within the lab. Figure 3 illustrates the games and platforms played by the participants during each session.

<Figure 3 about here>

3.2. Preliminary analyses

Categorizing breakdowns and breakthroughs

Initial analysis sought to identify instances within the data (approximately 12-14 hours of recorded play plus 16 post-play interview transcripts) that could be considered as breakdowns or breakthroughs. Sharples' (2009) definitions of breakdowns and breakthroughs were used while consideration was also given to instances of interaction and illusion breakdowns (Ryan & Siegel, 2009). The post-play interviews were transcribed and INTERACT (Mangold International GmbH) was used to code the multiple data streams (i.e. recordings of the player, game-play and physiological signals). During this stage in the analysis it became clear that breakdowns and breakthroughs were occurring on three different, though related, levels; with respect to player action, understanding and involvement (initially presented in Iacovides et al., 2011).

In terms of player actions, a breakdown occurs when the player fails to execute an action within the game successfully. This could be due to pressing the wrong button, getting the timing of an action wrong, or in-game events, such as being hit by an enemy. In terms of player understanding, the most obvious breakdowns are when the player is unsure about what to do or where to go. With respect to player involvement, boredom and frustration are key indicators that player engagement has been disrupted.

Although breakthroughs are conceptualised by Sharples (2009) as relating to understanding (since they involve conceptual change), they can also be defined as occurring in relation to action; when a player successfully carries them out. Similarly, instances where a player becomes more involved within a game can be described as breakthroughs relating to involvement, i.e. when a player experiences satisfaction or flow. With respect to understanding, breakthroughs occur whenever a player learns something about the game rules and mechanics or figures out how to solve a problem.

Physiological data (collected using the ProComp Infiniti system and sensors) was intended to help signify critical events but it was not found to be useful for identifying breakdowns and breakthroughs and is therefore not reported here. This was due to the difficulty of interpreting the signals in relation to the large data set, the lack of consistent patterns and the impact of observation. Further details can be found in our article considering the methods we applied (Iacovides et al., 2013).

Collating important episodes and issues

During the preliminary analyses, 53 episodes and issues were selected for further analyses. Episodes were classed as important when the player noted they were stuck within the game, or when they expressed frustration or boredom within the game. Boss fights (where the player has to defeat particularly difficult enemies at the end of a level)

were also included as tests of player skills and knowledge. Issues were classed as important if they related to recurring problems, e.g. with the controller, or if they represented underlying problems that affected the player's understanding or involvement, e.g. failing to understanding a specific game mechanic or not being interested in the narrative. The emphasis on breakdowns reflects a methodological decision to focus the research, rather than a position that these are the only points where learning occurs.

3.3. Developing claims about involvement and learning

As part of undertaking a multiple case-study analysis, Yin (2009) describes the iterative process of explanation building: make an initial theoretical statement or proposition; consider the statement in terms of an initial case; revise and compare with further cases; repeat as needed. Consistent with this approach, a number of initial statements were proposed, based on previous literature, that refer to suggested relationships between macro involvement, micro involvement, breakdowns, breakthroughs and learning. The initial claims are described below.

Initial claims

i. People's macro level expectations and choices depend on different player communities
ii. Continued micro-involvement depends on macro level player expectations being met

The first two claims consider the relationship between micro and macro involvement. They were based on the findings of a previous interview study with casual players and gamers (Iacovides 2012). The findings of this study suggested that player expectations and subsequent choice of games were influenced by resources such as paratexts, and by other people. Further, initial player expectations appeared to influence the assessment of a game-play experience and subsequent involvement.

iii. Breakdowns in action and understanding are not detrimental to involvement
iv. Player involvement increases through action and understanding breakthroughs

These two claims concern how the different types of breakdowns and breakthroughs relate to each other. The third claim stems from research which claims that minor breakdowns are a common part of game-play and do not disrupt involvement (Barr, 2007; Ryan and Siegel, 2009). The fourth claim considers previous research which acknowledges the influence of progress and reward on involvement (Calvillo-Gamez et al, 2010; Iacovides, 2012). Both claims were also influenced by research that highlights the importance of challenge within game play.

v. Progress requires breakthroughs in understanding

The fifth claim is based on literature that suggests "the assessment of the 'success' of the game is largely through completion of tasks or levels, individual and group scores are worked out on the basis of race speed times" (de Freitas, 2006, p.33). It also relates to a previous player interview study which highlighted the influence of progress on learning (Iacovides, 2012).

vi. The unpredictability of outcomes contributes to what makes games meaningful and compelling
vii. A loss of agency leads to a breakdown in involvement

The final claims were developed in relation to research that highlights the importance of agency within the game-play experience. For instance, regarding the PIM and involvement within the kinesthetic frame, Calleja (2011) states "the unintended and unpredictable consequences of one's actions are precisely what can make the exertion of agency in games so meaningful and compelling" (p. 58).

3.4. Assessing and revising the claims

The final stage of the analyses involved assessing the validity of the initial claims through a critical examination of the data set, which included: the introductory interview transcripts (from the first session); the collated list of episodes and issues (compiled from observations and interview transcripts and coded in terms of the different types of breakdowns and breakthroughs); and the diary data (including the 294 responses within the diary entries and the diary interview transcripts). Nvivo8 was used to code the introductory interview, diary entries and diary interview for evidence of macro involvement e.g. talking to others, consulting paratexts; and micro involvement relating to the different types of breakdowns and breakthroughs. Evidence was sought that was either consistent or inconsistent with the claims in order to discern the conditions under which they applied and produce a more robust theory of learning and involvement.

The claims are evaluated below. A summary of the assessed evidence is provided before presenting a set of refined claims. For convenience, roman numerals (i-vii) are used for the initial claims and arabic numbering for the revised set (1-14).

Micro and macro involvement

i: People's macro-level expectations and choices depend on different player communities

There were several examples to support this claim within the data. In terms of player communities, players discussed games with other people and consulted paratexts. For instance, in the diary entries, Alex reported looking at gaming sites such as Kotaku and Eurogamer. Similarly, Justin mentioned *Final Fantasy XVIII* was recommended to him by a friend. Player choices were also influenced by other people; such as Matt buying *Defcon* as he thought it was something he and his housemates "could enjoy playing together".

However, the most commonly referred to source of player expectation was previous game-play. For instance, Linda's shared a long running interest in the Lego game series with her daughter, commenting that e.g. "we didn't like [Lego Indiana Jones 2] as much as the Star Wars and the Batman Lego was brilliant". Similarly, Matt had played previous *Silent Hill games*, Justin previous *Final Fantasy* games, Katy other *Zelda* games and Alex other *Super Mario* games; all of which shaped their current expectations. For instance, Matt stated that he bought *Silent Hill Shattered Memories*, "as I enjoyed the original Playstation version and I have heard good thing about this one".

In terms of choosing what to play, social situations also prompted game-play, such as Natasha and William playing *Big Brain Academy* at a party. On the other hand, for Amy, the presence of other people was a disincentive due to concerns about competence: "I tend to prefer to play Mario Kart on my own… cos I'm not very good, I'd rather be beaten by the computer than by other people!". Price is also a factor; Nick, Alex and

Natasha all mentioned downloading mobile games because they were free. Mobile games in particular were played in "short bursts" e.g. waiting for the oven to heat up (Nick), indicating that deciding which game to play can depend on the amount of time available. Further, the accessibility of gaming platforms also influenced play. For instance, Natasha reports playing on her mobile phone when travelling: "I spent a long time travelling on buses, planes and taxis to Paris, so I played a variety of games on my iPhone".

ii: Continued micro-involvement depends on macro-level player expectations being met
There was some evidence to support this claim in the form of repeated play of the same game. For instance, Alex played *Super Mario Galaxy 2* several times during the study and he discussed in the introductory interview how he expected the game to include platform and exploration elements, while boss fights are "always good fun". However, with respect to Natasha and William playing *Doctor Who*, it was clear the game did not meet their initial positive expectations (as it was quite "buggy" and they were having trouble progressing) and so they quit and did not go back to it. The latter example shows how micro involvement is disrupted when expectations are not met.

In general however, this was one of the harder claims to evaluate as players did not always refer to their initial expectations when discussing their game-play experiences. Further, in some cases, expectations were only partially met but players still went back to the game, despite being bored with aspects of it e.g. Justin reported having to "trudge" through part of *God of War* III and Alex stated "the 'travel' sections in Zelda feel like they get in the way for me more often than not".

Additionally, subsequent in-game experiences sometimes caused players to reassess their initial expectations. For instance, Matt reported being initially disappointed with *Metro 2033* as it was not the open sandbox game he expected, but was impressed enough with the story and atmosphere to complete the game. In contrast, he assumed *Silent Hill: Shattered Memories* would be like other games in the series but was surprised to discover, in relation to the monsters he encountered: "I don't think you kill them, I think you've just got to run away from them". Expectations could also affect how a player interprets a game in the first place, mistakenly in the case of Katy and *Kameo*. Prior to play, she read the back of the box and later explained "I had no idea what I was walking into, beyond it would involve some fighting and some vague pretence at a story". Although there were moments when she thought the plot may have been more complex, she soon decided it wasn't and appeared to take the game less seriously as a result.

Other issues influenced whether a player went back to a game, including: stronger preferences for other games (e.g. Natasha and William going back to *Angry Birds* after trying out other iPhone games) and stronger preferences for different platforms (e.g. Nick spending more time on PC and iPhone games than using his Xbox 360). Price seemed to play a role in how much time players were prepared to invest in a game. For example, Nick mentioned several free iPhone games he tried once but gave up on, as did Natasha and William. In contrast, Matt and Justin made points about the amount of money they spent on console games and wanting to get the most out of them: "I do try to make a point of finishing games… mainly cos I spend all that money on it, I want to see what

happens" (Matt). Those who identified as gamers indicated that they were more likely to persevere with less enjoyable parts of games in order to achieve later rewards e.g. Justin describes *Final Fantasy XIII* as "it's like any RPG in the sense that, you've been grinding for long enough that you've now actually got some abilities <laughs> and some actual powers so it's more fun". However, further research would be needed before making generalisations about populations such as player types.

Summary
The data presented indicated that interactions with player communities, whether directly through talking to others or indirectly via paratexts, do contribute to player expectations of game-play. However, another important factor to consider was prior experience. Further, while player expectations being met during game-play did have an influence on continued micro involvement, other factors included the experience of game-play itself, the promise of later rewards, preferring other games and platforms, and even price. These findings are captured in the refined claims below:

1. Macro-level expectations are informed by prior experience, other players and the wider community.
2. Repeated micro-involvement depends on expectations being met, in-game factors, such as rewards, and external factors, such as the price of the game.

Action, understanding and involvement
iii: Breakdowns in action and understanding are not detrimental to involvement
Throughout the sessions, there were many examples of minor action and understanding breakdowns that were not detrimental to player involvement. In fact, they were quite a common occurrence and usually overcome quickly. For instance, when Katy was trying to get past the steam vent in *Zelda*, she did not get particularly annoyed or frustrated by the situation.

However, there were situations when breakdowns did cause a problem, in particular when they impeded game progress. For instance, after repeated action breakdowns due to controller issues, Natasha got frustrated with *Doctor Who* and passed the game on to William. He played the game for longer but then gave up because you "could try something, which didn't work, but would work 5 mins later". Another example concerns Linda who experienced an underlying understanding breakdown while playing *Indiana Jones 2*. This was due to the fact she normally plays the game with her daughter (where a second player can easily switch to the character required); so while she knew how to switch her own character, she did not know how to switch the artificial intelligence character following her around. In the sessions, she reported being "cross" and "fed-up" with the fact she was not making any further progress.

Another issue which negatively influenced involvement concerned the consequences of action breakdowns. For instance, Justin became particularly annoyed when his death in *God of War III* led to him being returned to a far-away checkpoint. Similarly, Alex gave up on a level in *Super Mario Galaxy 2* when he ran out of lives after a boss fight; where trying again "would cause stress" as the boss "was quite involved to get to". In Amy's

case, she quit after 30 minutes of playing *LocoRoco: Cocoreccho* because she couldn't find enough of the LocoRoco's to progress: "I've spent quite a lot more time, in the second bit just feeling confused, and that does frustrate me about a game". This represents both an action and understanding breakdown since she had not mastered the game mechanics in order to uncover the extra LocoRoco's and could not figure out where she was going wrong.

There was also a case where a lack of initial involvement caused subsequent action and understanding breakdowns. When Nick was playing *Endless Ocean 2*, it was clear from the start he was not very interested in the game or the narrative. He experienced several problems, in particular with respect to interpreting the map and navigating to the correct locations. During the post-play interview he conceded: "I found it hard to concentrate on the game because I wasn't really enjoying it."

iv: Player involvement increases through action and understanding breakthroughs
There was mixed evidence to support this claim, though there were indications of player satisfaction that resulted from achieving progress. For instance, Justin expresses his relief at overcoming difficulties he was having in *God of War III*, where once he managed to progress to a new area "all of a sudden this was a lot more fun again". Similarly, in relation to Katy playing *Kameo*, after working out a strategy to defeat the boss, she became keen to find out "what's going to happen next?". Further, there were references in the diaries that showed how macro level activities such as consulting paratexts, helped overcome breakdowns, e.g. Justin checking a walkthrough for *Final Fantasy XIII* when he was having trouble progressing and Alex looking up some information about the train pieces he was collecting in *Zelda: Spirit Tracks*. Arguably, the breakthroughs achieved led to the players become involved again on a micro level.

In addition, while Amy was playing *Mario Kart*, her involvement often related placing one of the final three positions at the end of the grand prix trials (which consisted of a set 4 races), and after each race she would quickly calculate her score so she would have some idea of whether she could achieve this goal. Reflecting on her overall involvement in the session, she was more pleased with the final set of races where she got a bronze cup for a set of tracks she had not completed using a 100cc bike before: "maybe it's looking back, there's more enjoyment from that, because I achieved something at the end of it, whereas the two I played on 150 I didn't place, so it's kind of like, ok, that's fine but, it didn't achieve anything so there's less reward at the end of it". This suggests that action breakthroughs add to involvement when the player feels they have achieved something as a result.

There were several cases however, where it was difficult to pinpoint whether an action or understanding breakthrough actually increased a player's sense of involvement. For instance, when Nick was playing *Fallout 3,* he did not experience any particularly significant breakdowns but neither where there any involvement breakthroughs. However, perhaps the action breakthroughs maintained his experience of involvement throughout the session since he did report enjoying it. Similarly, when Katy was playing *Kameo*, she came across a flame monster enemy she originally thought was invincible

since she had trouble defeating it. Eventually, she reached a point in the game where she could no longer avoid them so after trying out different attacks, she developed an effective strategy. However, she did not exhibit or report much of a reaction to these breakthroughs in understanding and action, perhaps as this was a minor enemy and so defeating it, unlike the later boss, did not result in a great sense of achievement.

Summary:
The evidence suggests that a lack of initial involvement may lead to action and understanding breakdowns since the player will not be paying enough attention. Further, breakdowns in action and understanding are not necessarily detrimental to player involvement providing they are overcome relatively quickly and have no major consequences. Rather than increasing involvement, breakthroughs often seem to maintain involvement. An involvement breakthrough seems to require a sense of achievement, experienced as a result of reaching specific goals or through overcoming significant obstacles. These findings are presented in the following refined claims:

3. A lack of initial involvement will cause further breakdowns.
4. Involvement will be reduced when breakdowns take too long to overcome or have major consequences, e.g. a loss of progress.
5. Action and understanding breakdowns help to maintain involvement when they lead to breakthroughs.
6. Involvement breakthroughs can occur when overcoming breakdowns leads to a sense of achievement.

Progress
v: Progress requires breakthroughs in understanding
There was evidence of progress being dependent on understanding breakthroughs within the game but they were not always necessary. When Natasha and William were playing *Little Big Planet* it was clear that communication facilitated understanding breakthroughs which led to progress. For example, at a particular impasse, both carried out different actions, such as investigating jet packs and exploring the area, but it was not until William asked "What are we actually meant to do?" and Natasha pointed out the drawbridge that he realised they had to lower it. Further, it was William picking up a cylinder and moving it to the other side of the screen that helped Natasha to figure out: "Maybe if we fill that thing with stuff, it comes down". In this instance, not only did they have to work out a solution before proceeding but one player's actions caused the other to realise what the solution was.

There were also several instances where progress was achieved in the absence of understanding breakthroughs. Amy did not experience any particularly significant breakthroughs while playing *Mario Kart*, apart from perhaps realising that she had forgotten to use manual cornering in one set of races. By the time she noticed this, the race was almost finished and she did not have enough time to significantly improve her position. As a racing game she was familiar with, there were few problems to solve and there appeared to be less scope for understanding breakthroughs to occur.

In other instances, progress occurred but without a complete understanding breakthrough. For example, in *Sam & Max*, Matt experienced partial understanding breakthroughs in the sense that he knew that he had to knock out Whizzer (one of the characters) within Bosco's store. Matt also knew that in order to do so he needed to plant an item (some cheese) on Whizzer so that when he tried to leave the store the security system would knock him down. However, Matt struggled to find a way to plant the cheese without being seen. In the end, Matt resorted to clicking on all the items in the room, just "hoping something would happen". He eventually clicked on the bathroom door, causing a chain of events that resulted in Whizzer leaving the room, allowing Matt to plant the cheese successfully. This was not a complete understanding breakthrough however, as Matt did not anticipate this chain of events – in fact Matt didn't know what to do next so he resorted to trial and error and accidentally found the solution. Ultimately, it was an action rather than understanding breakthrough which led to progress. While he knew what he had to do, he did not quite know how to do it: "And that's what kind of a bit annoyed me because it's like, you know what you've got to do, it's just you've got to do it in the way the game designer wants you to do it".

Other players also resorted to trial and error strategies when stuck, as opposed to working out a solution first. For example, Linda reported in her diary entries that she ended up "randomly stabbing" at the DS screen while playing *Jewel Quest*, since she found the objects too difficult to actually find. Justin also had a similar problem to Matt when playing *God of War III* and trying to solve a labyrinth puzzle. During the diary interview, Justin explained how the puzzle involved an elaborate setup but while he tried numerous different things, it was not until he was using a gem to adopt a different perspective that he inadvertently came across the solution, which actually "made no sense". So again, an action rather than an understanding breakthrough led to progress.

Summary:
In general, progress cannot occur without action breakthroughs, since they relate to the successfully execution of strategies. While understanding breakthroughs are an important part of achieving progress they are not always necessary. It is not just about finding a solution to the problem, but about working out the designer's solution to the problem, which may not be the same thing. Achieving an understanding breakthrough can speed up progress but the interactive nature of game-play means that trial and error may also work; though this was often less satisfying. The findings are represented in the following refined claims:

7. Progress requires action breakthroughs, but not necessarily understanding.
8. Action breakthroughs that occur without understanding will be less satisfying.

Agency, meaning and compelling game-play

vi: The unpredictability of outcomes contributes to what makes games meaningful and compelling
There is some evidence to suggest that the unpredictability of outcomes can make games more compelling and meaningful when the player interprets the outcomes as being fair

and consistent with the game-world. This was another difficult claim to assess as it was generally easier to identify instances where a lack of predictability made the gaming experience less compelling, rather than the other way around. For instance, when Matt realised he could only be harmed in the nightmare realm of *Silent Hill* he subsequently interpreted events outside of these sections as "less scary cos they just, nothing hurts you". Justin did experience unpredictable outcomes as enjoyable, e.g. when he realised he could ride Cerberus and use him to breathe fire: "Ok this is cool". However, his experience of *God of War III* also illustrates how unpredictability can be frustrating, e.g. when he decided to back track to explore a previous area but died several times due to difficulty performing double jumps. Justin felt that despite the fact he was performing the same actions, they led to unpredictable results.

Similarly, most of the examples from the collated episodes and issues concern situations where unpredictability was interpreted as not being meaningful e.g. when participants mentioned in-game events as being "random" or "unfair". For instance, while Amy initially suggested she quite enjoys the "randomness" of *Mario Kart* (as this was seen to make the game less serious), she did not always interpret this positively during the gaming session: "it's frustrating when it's like that, where you're like, last corner and I'm in first, get hit by a red shell and suddenly I'm in fourth". Similarly, Matt's comments about the monsters randomly spawning in *Silent Hill* being "unfair" indicate he did not find their occurrence particularly meaningful or compelling. The unpredictability of outcomes appears more likely to be interpreted as meaningful or compelling when the player feels responsible for what occurs and the results are seen as being consistent and fair with respect to the rules of the game (this is further discussed in relation to Claim vii below).

Other examples of unpredictability related to game narratives, which could be interpreted positively and negatively, as in the case of Linda playing *Bayonetta*. She was initially amused by the voice-over talking about "European clans" feuding with each other but she soon lost interest with the increasingly complex plot during the lengthy cut scenes: "I got bored and I was looking at the ribbons and I thought have they got some kind of secret language written on them or something". Another factor which may facilitate whether unpredictable outcomes are interpreted positively is the presence of others. When Natasha and William were playing *Little Big Planet*, there was a specific section in the Swinging Safari level when they both died multiple times. They found this amusing, both laughing at each other during the process. However, while William was keen to restart the level and try again after they ran out of lives, Natasha said doing so was "kind of annoying" as it meant they had to "do the bits that you've already done". Her reaction suggests that she did not find the unpredictability of the game quite as compelling as William did.

vii: A loss of agency leads to a breakdown in involvement

Agency within the game is exerted via the game controllers. While there was evidence to support this claim, in many cases, controllers problems were overcome by repeated attempts and did not take long to resolve i.e. minor action breakdowns occurred which did not affect involvement (as explained in Claim iii). For instance, Katy during the *Zelda*

session saying “Hey register” to the controller and commenting that Epona (Link’s horse) did not always respond the way she wanted her to. However, she did not report being particularly annoyed by the episodes. Similarly, Justin experienced issues when trying to line up party members to perform tasks in *Little King’s Story.* Here, he did become irritated with the difficulty he was having and even stopped the game to look at the manual for instructions. While he did not find anything useful, after a few more attempts he finally “twigged it".

However, Amy experienced more serious controller issues in *LocoRoco*. She was not very familiar with the PS3 controller and although the instruction screen at the start of the game was initially helpful, she became apprehensive as she received more and more instructions. She did suggest that as she starting playing “everything makes sense once you’ve seen it”, but later grew frustrated when she couldn’t work out how to find the number of LocoRoco she required. Although she had mastered the basic controls, she did not realise the extent to which she could interact with the environment; in terms of shaking and tilting the controller within different areas to manipulate the environment. Despite coming up with ideas, e.g. thinking underwater bubbles might be useful, the controller issues were an obstacle to her expression of agency. This limited her ability to interact with the game world and progress within it. Similarly, when Alex was playing *Flower*, he experienced a reduction in agency because he was unable to control the petal stream as effectively as he wanted. This became a more significant problem when he reached a canyon sequence and the game appeared to take over control of the stream. Alex described the experience as being an “on rails type thing” which he did not find it very satisfying so soon quit the session.

Matt also became frustrated with dying in the nightmare realm while playing *Silent Hill* but this had less to do with his character’s death, and more to do with the fact he did not think he had done anything wrong: “I just got trapped, I went under the bed but he found me, twice and then I’m trying to run away which is a dead end anyway and as soon as one found me, all three found me, which was quite annoying. I was like, that’s not fair at all”. This indicates, in addition to an understanding breakdown (not knowing how to avoid the monsters), Matt experienced a breakdown in terms of involvement. Using the phrase “unfair” suggests a loss of agency, where he saw the game as being at fault rather than himself. During the diary interviews, Matt also discussed how he continued to find the game-play in the nightmare world “arbitrary” as there he could not find a way to avoid the monsters entirely, thus contributing to his growing lack of interest in the game.

Similarly, while playing *Big Brain Academy*, Natasha experienced frustration in response to finding aspects of the Brain Quiz unfair. This mini-game involved competing for the highest score, taking turns on each round until a certain number of trials were completed. The game randomly calculates the difficulty level of each round, e.g. easy or expert, and allocates random bonuses to players, e.g. doubling their score. During these rounds, Natasha received a number of tasks with higher levels of difficulty, while William received a large number of bonuses. Although Natasha laughed about it, it was clear she had become a bit frustrated by the issue declaring that “it’s not fair” and suggesting to William “you’re a cheat”.

Summary
The evidence indicates that the unpredictability of outcomes can make games more compelling and meaningful (and this may be amplified in a social setting) but only if the player interprets these outcomes as being fair and consistent with the game-world. Unpredictability with respect to narrative also has an influence on whether how in-game experiences are interpreted. Further, a reduced sense of agency is very likely to lead to a breakdown in involvement, and is usually the result of recurring controller problems that influence progress or when players feel that their actions do not have meaningful consequences within the game-world. The revised claims are:

9. The unpredictability of outcomes leads to meaningful and compelling experiences but only when the outcomes are interpreted as fair and consistent within the game world.
10. Narrative and social context contribute to what makes a game play experience meaningful and compelling.
11. Additionally, an involvement breakdown will occur if game-play outcomes are not considered fair and consistent.
12. The experience of agency is necessary for maintaining involvement.
13. Recurring controller problems are an obstacle to the expression of agency.
14. Agency is reduced if players feel their actions do not have a meaningful impact within the game world.

4. DISCUSSION

4.1 Addressing the research aim

This article presents a theory of how involvement and learning come together in practice within the context of gaming. The theory is represented by a set of 14 claims. Learning is seen to occur on the macro-level in terms of acquiring gaming knowledge from other players and external resources; and with respect to micro-involvement in the form of experiencing understanding breakthroughs. Claims 1 and 2 illustrate the relationship between micro and macro level involvement. Claims 3-14 cover how different types of breakdown and breakthrough influence each other in terms of action, understanding and involvement; how they relate to game progress; and how they relate to agency, meaning and compelling game-play.

While previous literature indicates that people have different general motivations for playing games e.g. a desire to be challenged or wanting to share the experience with others (Lazzaro, 2004), this study illustrates motivation to play a specific game derives from a mix of macro level involvement (talking to others, engaging with paratexts) and prior micro involvement (previous experience of the game or similar games). Further, the findings suggest how in-game factors, such as rewards, and external factors, such as price, are able to motivate repeated micro-involvement.

As in previous research, breakdowns, in the form of challenges or aporias (Aarseth, 1999), were found to be an integral part of play. However, while Ryan and Siegel (2009) suggest that all interaction breakdowns lead to learning, our analysis indicates that

learning will only occur if there is a subsequent breakthrough in understanding. Applying the concept of breakthroughs to analysing game-play extends Sharples' (2009) work and allows for a more nuanced understanding of how learning occurs in this context. Further, while involvement breakdowns appear quite similar to the concept of illusion breakdowns, Ryan and Siegel (2009) were not clear about how these relate to interaction breakdowns. The refined claims clearly indicate that some breakdowns are catastrophic and lead to disengagement from the game (e.g. when they take too long to overcome or lead to a loss of progress) while others contribute to progress (via action breakthroughs) and learning (via understanding breakthroughs). Having the right balance between challenge and skill can help the player overcome breakdowns, but the findings also suggest that while both action and understanding breakthroughs influence involvement, progress without understanding will be not be as satisfying.

The data indicates that action and understanding breakthroughs do not guarantee an increase in involvement; heightened involvement seemed to occur only when the player experienced a sense of achievement as a result of a breakthrough e.g. after defeating a difficult enemy. The player needs to feel their actions have meaningful consequences within a game world that is considered consistent; otherwise they lack a sense of agency. While other factors such as narrative and social context can also contribute to what makes game-play meaningful and compelling, the findings support research that highlights the importance of being able to exert ownership and control within the game world (e.g. Calvillo-Gamez, Cairns & Cox, 2010).

This research has considered user experiences as rich and complex (Wright et al., 2003). Rather than trying to isolate elements that support a positive experience, we illustrate how action, understanding and involvement (micro and macro) interact with each other. Wright and colleagues (ibid) place emphasis on sense-making as central to experience, and describe how this process involves recursive anticipation (revising anticipation based on what actually happens); connecting (responding viscerally to material components); interpreting (providing meaning to the experience); reflecting (within and on the experience); appropriating (relating the experience to other experiences) and recounting (telling others about the experience). The revised claims reflect these different facets by considering the role of previous game play experiences, participant expectations and the basis upon which these expectations are revised. The claims also capture the way in which game-play is interpreted through cycles of breakdowns and breakthroughs, how action and understanding influence involvement (and vice versa) and the influence of macro and micro level interaction with other people and external resources.

The initial concept of breakdowns and breakthroughs within the area of mobile learning technologies (Sharples 2009; Vavoula & Sharples, 2009) has been extended to apply in the context of games. While emotion and contextual factors are already being considered within HCI as important aspects of the user experience (e.g. Hassenzahl, Schöbel & Trautman, 2008), focusing on how breakdowns and breakthroughs occur in terms of action (what people do - usability), understanding (what people think - learning) and involvement (what people feel - user engagement) could prove to be a useful way of evaluating interactions with technologies beyond mobile learning tools and games.

The claims themselves can also be applied to consider other technologies. They indicate how macro level experiences (e.g. talking to others, advertising) relate to micro level experiences (e.g. influencing user expectations) and vice versa (e.g. troubleshooting online after breakdowns occur). Further, they explain why individuals give up on certain technologies e.g. clunky interfaces and complex functionality lead to respectively repeated action and understanding breakdowns. The claims also suggest why supporting agency is so important and how overcoming challenges (e.g. in the form mastering a software tool) can increase involvement, through experiencing satisfaction, thus leading to longer-term use. However, while the experience of failure and overcoming it is commonplace in games (Aarseth, 1999; Juul, 2009) people may have lower tolerance for challenge in different contexts. Further, the claims do not account for why some people give up after only one or two breakdowns while others are prepared to persevere – this is something that can be addressed by further research and that is likely to be of interest to both HCI and games researchers.

4.2 Commercial and educational game considerations

The breakdown and breakthrough categories can serve as a useful method for evaluating the GUX and providing insights to designers. For instance, the categories could be used to compare the occurrence of breakdowns and breakthroughs during the testing of prototypes. The different types of breakdown and breakthrough (action, understanding and involvement) would help to pinpoint what kinds of problems are occurring, and when a "natural" breakdown turns into a more significant issue.

The claims can also help designers to think about the GUX in terms of both learning and involvement as they are based on empirical evidence which illustrates how learning, in the form of understanding breakthroughs, is an important part of game-play. The findings support the position that challenge is important, but emphasise that overcoming challenge and feeling responsible for doing so are key (Claims 6 and 14). Similarly, in relation to immersion, (Cox, Cairns, Shah & Carroll, 2012), involvement is seen to break down when the challenge is too difficult (leading to frustration) or too easy (leading to boredom). The claims also highlight other aspects of game-play that will influence involvement, such as the extent to which players interpret outcomes as being fair and consistent within the game world (Claims 9 and 11).

For educational games, designers are often faced with the difficult goal of developing games that are involving and able to support learning. There is mixed evidence of the success of games used for educational purposes (O'Neil, Wainess & Baker, 2005) where it has been argued these results "may indicate that learning through immersive worlds involves a more complex understanding of learning, one that is not so easy to tie to specified learning outcomes" (p. 18; de Freitas, 2006). The findings presented in this article not only help contribute to a more nuanced understanding of learning in games but also of how to maintain the relationship between learning and involvement, so that the motivational power of games (Kirremuir & McFarlane, 2004) can be harnessed more effectively.

All the claims are relevant to the development and use of games for educational purposes, with some particularly important to consider. Claims 1 and 2, about the relationship between micro and macro involvement, highlight that students will have expectations based on their previous experience of both commercial and educational games. Claim 3 highlights the impact of a lack of initial involvement on further action and understanding breakdowns, making it particularly important to ensure a good GUX from the beginning so that players can revise any initial low expectations. Claims 7 and 8 warn that action breakthroughs can be independent of learning, though these will then be less satisfying. Games therefore are not an easy way to engage students in subjects they are not particularly interested in as progress can occur without understanding. Ideally, there should be close integration between game mechanics and learning outcomes (Habgood & Ainsworth, 2011) so that progress and understanding are linked. Through ensuring that challenges can only be overcome via understanding breakthroughs, designers will support a positive experience of involvement and ensure students keep playing.

4.3 Directions for further research

The claims contribute to a deeper understanding of learning and involvement, but do not represent a definitive theory. In accordance with the Popperian approach adopted, phrasing the claims as testable conjectures allows for a continuation of their critical assessment, further refinement and elimination of any erroneous ideas they may contain.

For instance, there is scope to examine the influence of player expectation through studies which explicitly assess expectations before relating them to micro-level experiences. Similarly, investigating on players' views on outcome predictability could investigate the relationship to outcomes being interpreted as meaningful and/or compelling. There could also be scope to explore the effects of novelty on the GUX. There was an indication that gamers (as opposed to more casual players) were more likely to persist in the face of breakdowns, further data is needed to establish whether this is the case. In addition, it was often difficult to assess whether involvement had increased (or decreased) during the sessions, research that reviews the claims using more objective measures would be valuable.

Future investigations could also evaluate the claims in a wider range of circumstances. The study sought to include a range of game playing experience, however the games played in the lab were all console games. The diary data provided some tracking of breakdowns and breakthroughs outside of the lab context and on a broader range of platforms, however the data captured was less detailed than that collected within the observed sessions. Further, while the sessions involved a range of genres, the majority of games entailed the player interacting within a game world where they controlled some sort of avatar within a, usually, 3D space (a notable exception being *Big Brain Academy*). Further work is required to assess the refined claims when applied to a wider range of platforms and game types such as mobile or social network games.

In conclusion, the 14 claims theorize how learning and involvement come together in practice within the context of gaming. The work introduces a multiple case-study approach and builds upon the previous research on breakdowns and breakthroughs

(Pelletier and Oliver, 2006; Barr, 2007; Ryan and Siegel, 2009; Sharples, 2009; Vavoula and Sharples; 2009). The categories of breakdown and breakthrough can also be used as an analytical tool for analyzing interactions from an HCI perspective. We believe the refined claims provide a resource for game designers of both commercial and educational games and serve as a useful foundation for future research.

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Figure 1: Observation of the game-play

Figure 2: Participants in each case [G represents those identified as Gamers, NG represents those that did not]

	1. Matt	2. Katy	3. Linda	4. Justin	5. Alex	6. Nick	7. Amy	8a. Natasha	8b. William
Gender	M	F	F	M	M	M	F	F	M
Current age	24	23	59	32	41	29	28	31	32
How often they play	Several times a week	Daily	Several times a month	Daily	Several times a week	Weekly	Less than once a month	Several times a month	Once a month
How long they play	3hrs	2-3hrs	3hrs	2hrs	1/2hr	2hrs	2hrs	1hr	2hrs
Identity	G	G	NG	G	G	G	NG	NG	NG

Figure 3: Games played during the observation sessions

	Session 1 – Player choice	**Session 2 – Researcher choice**
1. Matt	*Silent Hill: Shattered Memories (Wii)*	*Sam & Max: Save the World (Wii)*
	Survival horror	Point-and-click adventure
2. Katy	*Zelda: Twilight Princess (Wii)*	*Kameo: Elements of Power (Xbox 360)*
	Action-adventure	Action
3. Linda	*Lego Indiana Jones 2 (Wii)*	*Bayonetta (PS3)*

	Puzzle/platform	Action
4. Justin	*God of War III (PS3)*	*Little King's Story (Wii)*
	Action	Simulation role-playing
5. Alex	*Super Mario Galaxy 2 (Wii)*	*Flower (PS3)*
	Platform	Independent art game
6. Nick	*Fallout 3 (Xbox 360)*	*Endless Ocean 2 (Wii)*
	Action/role-playing	Simulation
7. Amy	*Mario Kart (Wii)*	*LocoRoco: Cocoreccho! (PS3)*
	Racing game	Puzzle/platform
8. Natasha & William	*Big Brain Academy (Wii)*	*Little Big Planet (PS3)*
	Brain training	Platform