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Many people believe that educational games are effective because they motivate children to actively engage in a learning activity as part of playing the game. However, seminal work by Malone (1981), exploring the motivational aspects of digital games, concluded that the educational effectiveness of a digital game depends on the way in which learning content is integrated into the fantasy context of the game. In particular, he claimed that content which is intrinsically related to the fantasy will produce better learning than that which is merely extrinsically related. However, this distinction between intrinsic and extrinsic (or endogenous and exogenous) fantasy is a concept that has developed a confused standing over the following years. This paper will address this confusion by providing a review and critique of the empirical and theoretical foundations of endogenous fantasy, and its relevance to creating educational digital games. Substantial concerns are raised about the empirical basis of this work and a theoretical critique of endogenous fantasy is offered, concluding that endogenous fantasy is a misnomer, in so far as the "integral and continuing relationship" of fantasy cannot be justified as a critical means of improving the effectiveness of educational digital games. An alternative perspective on the intrinsic integration of learning content is described, incorporating game mechanics, flow and representations.

KEYWORDS: computer-based learning; computer games; digital games; edutainment; endogenous fantasy; instructional games; intrinsic integration; intrinsic fantasy; intrinsic motivation; video games.

The past twenty-five years has produced a substantial body of psychological, educational and development literature highlighting the educational potential of digital games (e.g. Gee, 2003; Kafai, 2001; Loftus & Loftus, 1983; Malone & Lepper, 1987; Prensky, 2001; Reiber & Matzko, 2001). However, this enthusiasm is tempered by the recognition that the majority of commercial 'edutainment' products have been wholly unsuccessful in harnessing this potential to effective educational use (e.g. Kirriemuir & McFarlane, 2004; Trushell, Burrell, & Maitland, 2001). Papert (1998) even goes as far as to describe these unsuccessful attempts as "Shavian Reversals" – combinations that have inherited the worst features of both digital games and learning. This is despite a growing realization that the best commercial digital games naturally employ a wide range of cognitive and situational learning techniques to significant effect for their non-educational aims (Amory, Naicker, Vincent, & Adams, 1999; Gee, 2003). While budget and market considerations have obviously contributed towards this gulf, theoretical contrasts are evident and their identification is both commercially and theoretically important.

One of the earliest and most frequently cited explanations offered for the contrast between effective and ineffective educational games is that of intrinsic and extrinsic fantasy (Malone, 1980), later relabeled endogenous and exogenous fantasy (Malone & Lepper, 1987). Malone (1987) defines an intrinsic fantasy, as one in which there is an integral and continuing relationship between the fantasy context and the instructional content being presented. Nonetheless, this is a concept that appears to have a confused standing within the literature. While many works, such as Reiber (1996) and Dempsey (Dempsey, Lucassen, Gilley, & Rasmissen, 1993) cite the concept of endogenous fantasy without reanalysis, others including Kafai (1996), Fabricatore (2000) and Prensky (2001) offer their own reinterpretations. Some works, such as Loftus & Loftus (1983), Driskel and Dwyer (1984), Parker & Lepper (1992) and Kirriemuir & McFarlane (2004) cite Malone's work in other respects, but do not address this fundamental aspect of his theory. Despite the apparent contention, the literature has not produced a critique of endogenous fantasy. This paper attempts to address this by providing a review of the concept of endogenous fantasy and its relevance to creating educational digital games.

Intrinsically motivating instruction

Malone's work on computer games was carried out in the late 70s using games as a platform for studying intrinsic motivation, focusing particularly on what makes games fun, rather than on what makes them educational (Malone, 1981a). This early work used the existing literature on intrinsic motivation backed up by a number of empirical studies (described later) to develop a theory of intrinsically motivating instruction for digital games. This theory was based on three categories of individual motivations: challenge, fantasy and curiosity (Malone, 1980, 1981a, 1981b, 1983, 1984). It suggests that the motivational effect of a challenge depends on engaging a player's self-esteem using personally meaningful goals with uncertain outcomes. Uncertainty can be achieved through variable difficulty levels, multiple level goals, hidden information and randomness. It also proposes that it is the emotional appeal of fantasy and the sensory and cognitive components of curiosity that provide their motivational effect in digital games. It further suggests that cognitive curiosity is aroused when learners discover that their knowledge is incomplete, inconsistent, or unparsimonious.

Six years later this original theory was expanded to add control as an additional individual motivation and cooperation, competition and recognition as interpersonal motivations (Lepper & Malone, 1987; Malone & Lepper, 1987). This attributed the motivational effect of control to empowerment and self-determination, suggesting that it is affected by the range of choices offered by a game, the extent to which outcomes are dependant on the responses of the player, and the inherent power of these responses. In addition it proposes that the perceived level of control is more important to motivation than the actual level of control. The motivational benefits of both cooperation and competition are described, while acknowledging that the long-term effects of competition can be detrimental to motivation. Furthermore, it suggests that cooperation and competition are more motivating when they are based on dependant tasks where there is interplay between the players, rather than independent tasks that are completed autonomously.

Defining endogenous fantasy

As part of this theory a fantasy environment is defined as, "one that evokes mental images of physical or social situations not actually present" attributing it with educational benefits based on the distinction between intrinsic and extrinsic (or endogenous and exogenous) fantasy. An educational game with endogenous fantasy is said to have the following properties (Malone & Lepper, 1987, p. 240):

(a) "the skill being learned and the fantasy depend on each other"
(b) "there is an integral and continuing relationship between the fantasy context and the instructional content being presented".

Conversely an educational game with exogenous fantasy is defined as:

(c) "one in which the fantasy depends on the skill being learned but not vice versa"

and based on the empirical studies it is proposed that:

(d) "in general, endogenous fantasies are both more interesting and more educational than exogenous fantasies"

This theory has implicit appeal and seems to embody the idea of effectively transferring the intrinsic motivation produced by computer games onto learning content. However, this paper will go on to examine these claims and definitions by scrutinizing the empirical foundations of this theory. As a result, it will argue for an alternative viewpoint on integrating intrinsic motivation and provide a set of design guidelines based on this new perspective.

What makes computer games fun?

The taxonomy of intrinsic motivations for learning was inspired by a series of empirical studies carried out by Malone. Examining the progression of these studies provides an insight into the development of the taxonomy and the concept of endogenous fantasy. In the first of these studies 65 school children were interviewed about their computer game preferences (Malone, 1981a). These children had been playing computer games in a weekly class and were asked to rate 25 games on a four-point scale. These results were used to compare the popularity of the games with a number of features that were hypothesized to be contributing to their motivational success. The results showed a strong correlation between high ratings and games containing goals, scores, audio and randomness. It was concluded that goals were the most important feature determining the popularity of the games, but that in general there is great variation between the kinds of games that different children prefer.

It was acknowledged that it would be a mistake to use this co relational study to draw any definite conclusions (Malone, 1981a). Loftus & Loftus (1983, p. 33) also note that the games used were "relatively non-standard", presumably in so far as the games found in schools tend not to be 'mainstream'. In a measure of reliability, subjects completely changed their minds about whether they had played 11% of the games. It is not made clear how many children rated each game, but this shows that some were obviously unsure if they had played the games they were rating. This is not surprising, as it is noted that some had only been to two months worth of 45-minute classes, and so would have needed to change games every 15 minutes to play all 25 games. The results of this study might have been more convincing if the children had had the opportunity to play all the games in advance of rating them.

Another brick from the wall

The next study used an ablation technique on the now classic game of Breakout (see Figure 1) to try and more rigorously examine how specific design features affected its motivational appeal (Malone, 1981a). Despite the abstract appearance of breakout to the modern eye, it was this study that that first focused on fantasy as a significant design feature. Moreover, the way in which fantasy is discussed demonstrates a very broad view of its influence in game design, and a blurring between fantasy and other features of the game.

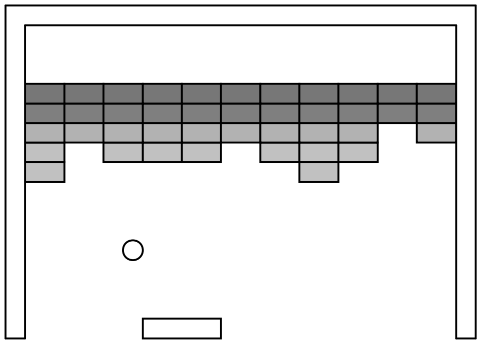

FIGURE 1. A diagrammatic representation of Breakout © 1976, Atari.

In breakout, the paddle (bottom) is moved left and right by the player in order to keep the ball in play as it bounces between the paddle and the wall. Each time the ball hits a brick, it disappears and the player's score increases. The level is completed when all the bricks are removed. Three features of the game were proposed as those that captured its essence: the score, the 'breaking of bricks' and the 'bouncing of the ball off the paddle' (Malone, 1981a, p. 345). Several variations of the game were then constructed with different combinations of these features. Ten undergraduates were given three minutes to play each version of the game and rated them on a scale of 1 to 5. The version containing all three features was found to have significantly better ratings than all the other versions, with 'breaking of bricks' being the most important feature, and the score and 'bouncing off the paddle' much less important.

Breakout analysis

In the discussion of the results it is suggested that 'brick breaking' is important in Breakout because it provides goals, visual effects, fantasy and an iconic scoring mechanism all in one feature. It is also claimed that the results support the idea that challenge and visual effects are important in the success of other games (Malone, 1981a, p. 349). While these are not outrageous claims in themselves, the experimental design does not seem to be capable of supporting them. Stopping the bricks from breaking is not only counter-intuitive, but breaks a fundamental aspect of the gameplay. It is precisely because it does so that it would be wrong to draw any more detailed conclusions about the effect that this feature had. It is a poorly designed ablation experiment that removes an essential component of the system without replacing it with a basic equivalent that still allows the system to function (Cohen & Howe, 1998). Adding additional features to the game of Breakout would have been a better way to study their effects on the motivational appeal of the game.

This study also raises concerns with the relatively small amount of time subjects spent playing each version of the game. Would the same judgments have been made given a longer exposure to them? Furthermore, half of the subjects had played the full version of the game before, and so their preconceptions may have caused them to rate the most familiar game format more favorably. Nonetheless, the argument for scoring as a significant feature is supported by this experiment, but no explanation is provided as to the apparent importance of bouncing the ball off the paddle. However, despite the prevalence of fantasy in the discussion, this study does not lend itself well to the justification of fantasy as a significant motivation in computer games.

Bursting fantasy balloons

This final study was the only one to empirically address the concept of intrinsic fantasy. However, it was not designed to measure learning outcomes and so cannot directly support the claim that intrinsic fantasies are more educational. In addition, the results for its motivational effect were mixed and the concept of intrinsic fantasy itself is not made any clearer through its implementation in this study. For this experiment an ablation technique was applied to an educational computer game based on fractions, called Darts (see Figure 2). Three balloons appear at random on a number line and players try to guess their positions by entering numbers containing fractions. After each guess an arrow flies across the screen at the entered position. If the arrow hits a balloon then it pops, otherwise the arrow remains on the number line with the incorrect guess written next to it (Malone, 1981a, p. 349).

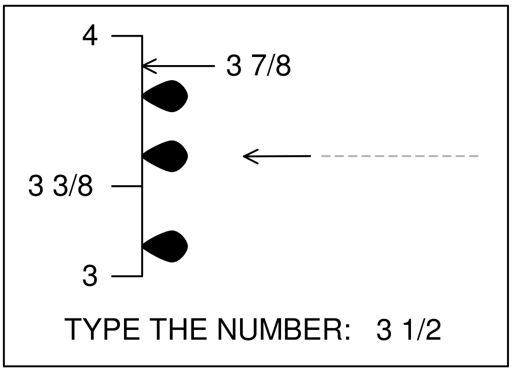

FIGURE 2. The screen layout of the original Darts game. Adapted from Malone (1981a).

Feedback, scoring, intrinsic fantasy, music and graphics were identified as potentially motivating features of the Darts game. Eight versions of the game were constructed, beginning with a version stripped of all features and progressively adding one more feature to each version, until the final version corresponded to the original game. The original game was considered to represent an intrinsic fantasy with the fantasy of balloons and arrows being intimately related to the skill of estimating fractions. The extrinsic fantasy version attempted to break this relationship by displaying the balloons as a separate scoring mechanism, away from the number line and replacing the targets with plain rectangles. Ten ten-year-old subjects were assigned randomly to each of the eight conditions and given the free choice between playing their version of the Darts game and an unchanging version of computer Hangman. The time spent playing each game was recorded over two twenty minute sessions with each child. At the end subjects were asked which game they preferred, and rated both games on a scale of 1 to 5.

Darts analysis

The analysis of the results showed that the boys played the version that contained extrinsic fantasy significantly more than the version without. There was no significant difference between the time boys spent playing the intrinsic fantasy version and the version without. The boys also played the version with written feedback significantly less than the version without. The girls actually played the original intrinsic fantasy version of the game less than the extrinsic fantasy equivalent but the version with music significantly more than the one without. An argument is made for attributing the girl's apparent dislike of intrinsic fantasy to an actual dislike of the fantasy of bursting balloons with arrows. This suggests that they disliked the intrinsic version the most because this integrated the fantasy – which they disliked – most effectively. It is concluded that while fantasies are important to creating motivating games, inappropriate fantasies can be equally detrimental to motivation.

Although this experiment is the most rigorous of three studies behind the taxonomy, the differing results for boys and girls preference for intrinsic fantasy offer very limited support for its potentially beneficial role in learning. In addition this experiment reveals some causes for concern regarding the theoretical foundations of endogenous fantasy itself. The way the study is structured implies that the versions that did not contain arrows and balloons were devoid of fantasy. Indeed, an earlier paper states that, "Non-fantasy games involve only abstract symbols" (Malone, 1980, p. 164). Yet, the rapid progress of technology has left the game's arrows and balloons looking very abstract to the modern eye. Is there really some kind of conceptual leap taking place in the mind of the player when a rectangle is swapped for a balloon-shaped blob, or is it just part of a continuum of graphical representations that would nowadays be a specularly-lit, bump-mapped 3D character? From this perspective the contrast between the intrinsic and extrinsic versions of the game begins to look more like a distinction between enhancing the 'sensory curiosity' of the number line or the scoring representation – and nothing to do with fantasy at all.

Testing the definition

The Darts experiment also provides a concrete example of an endogenous fantasy against which to compare the definition. This game is offered as a good example of an endogenous fantasy, "[…] where the fantasy (the positions of the arrows and balloons on the number line) is intimately related to the skill being used (estimating fractions)" (Malone, 1981a, p. 350), a justification that seems to meet up to his first definition, (a). Darts is contrasted with the exogenous fantasy of Hangman, which is said to be, "only weakly related to the skill being used (spelling and vocabulary)" in line with (c). However, the extrinsic nature of Hangman is further justified by suggesting that the same fantasy could be used for different subject matter. Yet in the same way 'abstract' rectangles and lines are swapped for the fantasy of balloons and arrows, we could swap the fantasy of balloons and arrows for the fantasy of elephants and current buns. If this was done by simply redrawing the graphics then it would seem absurd to suggest that this new game would be any less educationally effective than the old one. Therefore can we really say that there is "an integral and continuing relationship" between either of these fantasies and the learning content (b), or perhaps there are common elements to the realization of both these fantasies that are the real endogenous factors at work here?

The fallacy of digital daydreams

Throughout this work there seems to be an underlying conceptual viewpoint of fantasy as something that permeates all aspects of digital games. The wall in Breakout is described as a "visually compelling fantasy goal" (Malone, 1981a, p. 348), crediting the fantasy with producing goals and a scoring mechanism (challenges) as well as a visual effect (sensory curiosity). In a similar way the feedback provided by the visual representation of students' guesses in Darts is attributed to the "fantasy world of balloons on a number line" (Malone, 1981a, p. 361). Yet in both these cases the fantasy could be changed, or even – according to the definition of "non-fantasy" – completely removed, without losing any of the benefits given above. Exchanging the bricks or the balloons for abstract symbols such as crosses might decrease the motivational appeal of the game, but it would still function in the same way.

This would seem to suggest that the idea of a "non-fantasy game" is a misconception. Even the definition of a fantasy environment as, "one that evokes mental images of physical or social situations not actually present" (Malone & Lepper, 1987, p. 240) does not seem to exclude the possibility of abstract fantasies. Can a balloon that appears on a computer display really be any more physically real, or unreal than a rectangle or a cross? To say that it can seems to suggest a viewpoint where players reinterpret the sensory stimuli provided by a digital game in order to engage in their own introspective fantasies during play. They are in a kind of 'digital daydream', constructing their own mental imagery for the game in the same way as they might if they were reading a storybook. However, intensely interactive games like Breakout require the player's full concentration, and attempting to indulge in a fantasy while playing would only hasten a player's demise!

Psychological fantasies

Perhaps it is unsurprising that a psychological work should take this perspective, as the psychological study of fantasy has nearly always been connected to the psychodynamic study of daydreams (Freud, 1959; Klinger, 1971; Singer, 1975). In fact Singer also expressed the idea of creative media as externalized daydreams, "From the standpoint of the artist, daydreaming and fantasy are processes that are just there. Artists seek to capture them in prose, paint or music, and more recently on the moving picture screen" (Singer, 1975, p. 5). However the introspective nature of daydreams also carry with them the idea of fantasy as a unary concept. The decomposition of fantasy is the subject of an unresolved debate in psychology, and specifically as to whether fantasy is entirely composed of imagery and if fantasy can occur without imagery. It was the stalemate produced by the contrasting results of the two main antagonists that became one of the most significant justifications for the decline of introspective methods in psychology (Klinger, 1971, p. 136). Yet it seems to be this same unary idea of fantasy that is behind its apparent pervasiveness in these studies of digital games. If you regard a digital game as being analogous to a daydream, it then makes little sense to ask what would be left if you removed the fantasy from the daydream. Nonetheless this is the question that needs to be asked if we are to gain a clearer understanding of how the integration of learning content within a game affects learning.

Commercial fantasies

The perspective on fantasy presented in this paper is derived from commercial experience in the games industry and would attempt to decompose the fantasy context of a computer game into the elements that are required to implement it. This would include the contextual elements of the graphics, sound and music that set the game within a specific time and place, as well as the narrative and characterization that are created through the on going story. This viewpoint comes from a ludic perspective (Frasca, 2003), which sees the fantasy elements of games as quite separate from – and less significant to – the underlying rule systems of a game. This standpoint may seem to conflict with contemporary ideas on games and learning such as Gee's 'projective identities' (Gee, 2003) which attribute significant learning potential to the fantasy roles taken on by game players. Here a more intrinsic relationship between the fantasy identity of a character and the learning content (e.g. an alchemist and chemistry) might arguably prove more effective than an extrinsic one (e.g. a court jester and mathematics). However, the original experiments behind endogenous fantasy do not include character identities and we believe they allude to something more fundamental about the integration of learning content in games.

By this point the "integral and continuing relationship" of fantasy has become less convincing as a critical means of improving the educational effectiveness of digital games. We suggest that endogenous fantasy is a misnomer, which merely clouds our ability to distinguish the effect of fantasy contexts from the more precise distinctions between games.

Continuing to use the term endogenous fantasy in this context would therefore only stand in the way of gaining a deeper understanding of the real factors at work in creating educationally effective games. Consequently it is proposed that Kafai's, intrinsic and extrinsic integration (Kafai, 2001) is a more appropriate term to use to describe such contrasting approaches for integrating learning content in digital games. However, merely changing the term does not help to clarify its definition. Kafai's work with games made by children does not offer an explicit definition of what she sees as the dividing line between intrinsic and extrinsic games. This paper continues to offer the authors' theoretical analysis of these contrasts in an attempt to stimulate debate and discussion in this area.

Flow, core mechanics and representations

Research on optimal experience and flow was a central reference in the justification of challenges as part of the motivational taxonomy for computer games (Malone, 1981a). Flow theory proposes that clear goals, achievable challenges and accurate feedback are required to achieve a state of flow in an activity (Csikszentmihalyi, 1988, p. 34) and all of these are included as facets of the taxonomy. Although flow theory was based on a range of practical examples of the 'flow experience', the role of this phenomenon in the use of computer technology and digital games has not been studied until more recently (e.g. Chou & Ting, 2003; Ghani & Deshpande, 1994).

Feelings of total concentration, distorted sense of time, and extension of self are experiences that are as common to game players as Csikszentmihalyi's rock climbers and surgeons. There are a number of studies which associate the symptoms of flow with the negative effects of addiction (Chou & Ting, 2003; Fisher, 1994; Griffiths & Dancaster, 1995), yet is it is these kinds of experiences that seem to be at the root of the engagement power of digital games. Furthermore, these seem to be the very kind of experiences that are missing in the majority of edutainment products and could be a major factor in the distinction between extrinsic and intrinsic learning in digital games. Some edutainment products certainly interrupt the flow of the gameplay with their learning content, and others keep the learning quite separate from any flow experience, but few manage to make the learning content part of the flow experience.

Fantasy and game genres

While most game players would identify with flow experiences, it is unlikely that they would agree on which games provide them with the greatest sense of flow. Individual traits such as personality (Griffiths & Dancaster, 1995), taste and mood are likely to determine which types of game will provide a flow experience at any given time. Over the years the range of game genres has diversified in order to appeal to the preferences of an increasingly wider gaming audience. Digitally induced flow experiences are now offered in the form of immersive adventure stories, strategic war games, physical dancing games, intense sports games and gory shooting games, to list but a few.

Individual preferences can be partially attributed to the large differences among people in the fantasies they enjoy (Malone, 1981a), this is a good example of why the all-encompassing view of fantasy within games is such a misleading concept. Consider these three games all based around the same fantasy of being an army commander in a medieval battle: the first gives you first-person control of your commander, furiously fighting your way through the throngs of enemy soldiers; the second gives you strategic control of the battlefield, determining when your troops should advance and who they should attack; the third puts you in charge of training your army, making allies and managing the resources for the whole campaign. All of these examples could employ fantasies with the same storyline, the same characters and even the same graphics (from different perspectives), but represent a spectrum of game genres that appeal to completely different audiences.

Core mechanics

Individual preferences for different game genres are not directly attributable to the fantasy of a game but the "mechanism through which players make meaningful choices and arrive at a meaningful play experience" (Salen & Zimmerman, 2004, p. 317) – commonly referred to by game developers as the core mechanics. Core mechanics are the procedural mechanisms of a game that provide the essential interactions required to create a meaningful gaming activity. So the core mechanic of Breakout is in controlling the horizontal position of one object in order to repeatedly intercept another moving object and keep it bouncing around a confined space. Whether the game uses the fantasy context of a bat and ball or (as in a later interpretation of the game) a space ship and energy bolt, it makes no difference to the fundamental gaming activity – or the flow experience that it creates. The core mechanic of the Darts game is in entering fractional values that make one object hit another object, based on its position along the length of a third object. As already suggested these could just as well be elephants and current buns as balloons and arrows.

Core mechanics define the different game genres and the types of flow experiences they produce – and it is through the core mechanics of a game that many of the motivational effects of challenge, control, cooperation and competition are ultimately realized. Interestingly, fantasy is one of the few motivational effects that is quite separate from the core mechanics of a game. The choice and quality of the fantasy are hugely important in emotionally engaging the player's interest in the game, but the fantasy could be exchanged for another of equal merit without changing the nature of the flow experience created by the core mechanics of the game.

Representations

Malone observed that, "Endogenous fantasies can also provide useful metaphors for learning new skills […], and they can provide examples of real-world contexts in which the new skills could be used" (Malone & Lepper, 1987). There is a long tradition of research exploring how information should be represented to best support learning. Two points of contact with research on digital games are a) research concerned with designing representations that make explicit the key features of the domain, particularly through use of visual features and b) research that explores how including dynamic or interactive features can enhance learners' understanding. Research with visual representations that involve explicit geometric and topological information has shown that they allow learners to benefit from powerful perceptual inferences and reduce the amount of effort required to solve problems (Simon & Larkin, 1987; Zhang, 1997). Visual representations can support the construction of mental models, which is particularly important when learning about complex subject matter (Schnotz & Bannert, 2003). Visual representations can also enhance learners' metacognitive strategies encouraging them to make more productive use of materials and to learn complex topics more completely (Ainsworth & Loizou, 2003). Through employing visual representations in environments such as Microworlds and Simulations (de Jong & van Joolingen, 1998; Papert, 1980) learners can be encouraged to participate in interactive exploration of learning content (Miller, Lehman, & Koedinger, 1999; Papert & Talcott, 1997) and the links between these approaches and those employed by digital games are evident (Reiber, 1996).

While visual representations are often employed to aide understanding in edutainment software it is rarely possible for the learner to interact with them in an active way. Yet, it is through interactive manipulation of visual environments that learners can take active control of their own learning and in so doing construct a deeper understanding of the subject (Martin & Schwartz, in press). All this research seems to suggest that educational games would be more effective if they have intrinsic learning content, which is represented within the structure and interactions of the gaming world, and provides an engaging metaphor for understanding and exploring the learning content.

Endogenous learning in digital games

Based on the theoretical analysis offered in this paper, the following design guidelines are suggested for more intrinsic integration of learning content in digital games:

1. Deliver learning material through the parts of the game that are the most fun to play, riding on the back of the flow experience produced by the game, and not interrupting or diminishing its impact.

2. Embody the learning material within the structure of the gaming world and the player's interactions with it, providing an external representation of the learning content that is explored through the core mechanics of the gameplay.

However, while this may seem to represent a better approach to integrating intrinsic motivation than endogenous fantasy, there is still no evidence to suggest that such an approach would produce more effective learning. In fact, this definition actually makes it easier to see how a more integrated approach might actually produce less effective learning. It is possible that an intense state of flow may inhibit metacognition and may not represent ideal conditions for the acquisition of declarative knowledge. This may raise further questions about the type of learning material appropriate for intrinsic games of this kind and whether their true potential is in the proceduralization of knowledge rather than its initial acquisition.

These are just some of the issues that we are attempting to investigate empirically with the ZOMBIE DIVISION project (Habgood, 2005). This action-adventure game is based around a combat mechanic in which the player must use different attacks to mathematically divide numbered skeletons in hand-to-hand combat. Each of the player's attacks has a different divisor, and the mathematical relationship between divisors is embodied in the structure of the player's attacks (e.g. using the sword once divides by two, twice divides by four and three times divides by eight). The core mechanic could be described as "defeating enemies in combat by attacking each enemy with a divisor that divides their number into whole parts". In an extrinsic version of the same game, the numbers on the skeletons are replaced with pictures of the weapons that divide them, and players receive a separate division quiz of the same learning content at the end of each level. By comparing the learning outcomes of these two versions in a series of experimental evaluations we hope to be able to draw some conclusions as to the usefulness of the definition of intrinsic integration described in this paper.

FIGURE 3. A screenshot from the intrinsic version of ZOMBIE DIVISION.

Conclusion

This paper has examined both the theoretical and empirical foundations of endogenous fantasy and concluded that it cannot be justified as a critical means of improving the educational effectiveness of digital learning games. Instead the roles of flow, representations and game mechanics have been highlighted as factors more likely to affect the integration of intrinsic motivation and learning content within digital games. However, this does not mean that the motivational power of fantasy is not a significant factor in making an educationally effective computer game and it should not detract from the value of the motivational taxonomy. While the experimental studies do not make a great case for the taxonomy it still represents an implicitly valid insight into the motivational factors at work in digital games. This view is supported by one highly considered games-industry veteran who concurred that, while the taxonomy is not necessarily an exhaustive or exclusive categorization it still broadly agrees with his professional experience - even seventeen years after it was written (Penn, 2004). Nonetheless we believe that endogenous fantasy was the wrong term to use to describe this concept and hopefully identifying this should open the way for useful progress to be made in this area.

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