Battle of the Titans: Mario vs. MathBlaster

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Abstract

One way to understand how a particular medium can be used effectively in education is to study its outstanding examples, regardless of their original purpose. The argument can be made that many of the most successful commercial games already embody sound pedagogy in their designs even if that incorporation was not deliberate. The following paper will examine two games: one a commercial and critical success and the other designed deliberately as an educational game. The analysis seeks to answer the two questions: What do players need to learn in order to win the game?, and How does the game support that learning? A comparative analysis of both games reveals that although they are very similar in genre and type, there are several design lessons that can be learned from the commercially successful game.

Anyone who makes a distinction between games and learning doesn't know the first thing about either.

- Marshall McLuhan

Introduction

Studying “the masters” and learning from them directly or indirectly is a time-honoured tradition. It is at least in part, that upon which the practice of apprenticeship is built. We already know that people learn from digital games (Egenfeldt-Nielsen, S., 2005; Prensky, M., 2006; Squire, K., 2003) even if what they learn in those games is not currently valued by society. It has also been suggested that some games (i.e. the “good” ones) already embody sound pedagogy in their designs even if that incorporation was not intentional (Becker, K., 2006; Gee, J. P., 2003; Prensky, M., 2006). If teaching is defined as the facilitation of learning, then games certainly teach. Further, if we accept the proposition that commercially successful games already embody sound pedagogy, it would then follow that an examination of these games (the ‘masters’) can help us learn how to design games designed specifically for education.

This paper reports on the results of an analysis of two digital games: Knowledge Adventure, Inc.’s *Math Blaster: Master the Basics* for the PC (Davidson, J., 2006), and Nintendo’s *New Super Mario Bros.* for the Nintendo DS (Miyamoto, S., 2006). Both were examined as if they had been designed as educational games, even though only one of them actually was. The educational game, *Math Blaster* (Figure 1) has received high ratings from educators, but not from games designers. If we conjecture that games designers, by and large, are better equipped to evaluate the *game* qualities of a given game than are educators, then one expected outcome from such a comparison would be that the educational game lacks essential game qualities. Comparing the two will uncover some of these essential qualities.

Who are the “Masters” in the Medium of the Video Game?

Each major medium of human expression has its masters, whether it be fine art, dance, music, literature, theatre, film, or something newer. Even though sales rankings alone are not indicative of “master” status, they are still indicative of success in a medium where unit sales are the major source of funding for the industry. *Pirates Of The Caribbean: Dead Man's Chest* (Verbinski, G., 2006) was the third highest grossing (box office) movie of all time at the end of 2006[1] which at the very least indicates that a great many people were interested enough to pay to see it in the theatre, yet when viewed as an artistic creation, most people would not put it in the same category as *Casablanca* (Curtiz, M., 1942), for example. On the other hand if our goal is to learn about film-making, then both

[1] According to the Internet Movie Database (imdb.com), retrieved on Dec. 15, 2006.

films would probably be worthy of study, although perhaps for different reasons. Although important, commercial success can not be taken as the only measure of success as there are plenty of examples of artists, writers, and musicians of the past who lived lives of poverty and did not achieve critical acclaim until after their deaths. Therefore, if we wish to study the 'masters', we must use several measures of success instead of just one.

Even though computer and video games have been around for little more than forty years, this medium already has designers and individual games that are truly outstanding - having achieved critical acclaim, commercial success, or both. When it comes to video game design, the 'masters' are those who have created games that deliver a rich and memorable experience. The masters in this medium are the ones who produce games that consistently make the "best of" lists; the games that players remember; the games they buy and recommend; the games that spawn fan sites and entire fan communities. The series of games known as the *Sims* (Wright, W., 2000) are among the best selling games of all time (ESA, 2006), and most industry insiders would have no trouble referring to Will Wright, the Sims' creator as one of the "Masters". How did these games become so popular? This question turns out to be considerably easier to answer than why they are popular, so we will address that here. Evidence suggests that among the most important factors influencing sales of games are word of mouth referrals and game demos (Dobson, J., 2006). Game demos typically restrict play in one of several ways, the most common of which are: fewer levels of play, restricted access to terrain or capabilities, and time limits. Games are expensive and people like to try them out before they buy them. This implies that the actual experience of playing the game is of prime importance to a game's commercial success. This in turn means that the game must be designed in such a way that it effectively supports the players while they are learning how to play and it must do so well enough, while still leaving enough out, to convince people to buy the full version. Once the full version has been purchased, the game must fulfill the promise of the demo sufficiently to inspire purchasers to recommend the game to their friends and acquaintances. The game experience must be of interest to those wishing to take advantage of games as a medium for learning.

Commercial games can be assessed on their critical and commercial success quite reliably, but games designed specifically for education are more challenging. We tend to apply different standards to games for learning, and we have different expectations in terms of what we get out of them. If a game is presented as a learning game, certain affordances are willingly made. We expect less in the way of graphics and sound, and we accept games that are less interesting. This seems fair, given that the primary goal is learning, and fun should be subordinate to that. This should not, however be used to infer that striving for the highest quality of gaming experience is unimportant. As with any other design decision, each inclusion as well as each exclusion should be carefully examined and justified. Ignoring aesthetics, or allowing a game to be awkward or incongruous is unacceptable, regardless of whether the game is intended purely as entertainment, or as a learning object. In the case of this study two games were chosen in their respective categories because they were both highly rated by their own target audiences but since the two games were created for quite different purposes, it is not actually possible to equate the ratings of these two categories.

The Chosen Games

For this study *Super Mario* was chosen as the successful commercial game. It was chosen because of its generally high ratings and popularity2. In addition, an older game was chosen because these tend to be simpler in design than most current games, allowing for a relatively comprehensive evaluation in a fairly compact domain. Although the particular edition of the game examined was released in 2006 for the Nintendo DS handheld system, the game's design remains true to the original *Super Mario Bros. 3* (Miyamoto, S., 1990) and makes virtually no use of the touch screen during game play.

The educational game chosen was Knowledge Adventure, Inc.'s *Math Blaster: Master the Basics*. The Math Blaster series is well-known and critically acclaimed for helping children learn and practice math facts. The original Math Blaster concept was developed by Jan Davidson, who went on to found the Davidson Institute with her husband, as well as The Knowledge Adventure Company which publishes the Math Blaster Series and the Reader Rabbit series. The credits for the game include the Director of Development, who holds a M.Ed., as well as several educational consultants.

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[2] On August 24, 2006, this game sold its millionth copy in the U.S. http://ds.ign.com/articles/728/728176p1.html

Methodology

R.S. Peters, in Criteria of Education (1966, pp 25) states that it is impossible to consider education without implying some worthwhile and desirable change in the person being educated. Thus, analyzing an entertainment game as though it were an educational one when it was not designed as such necessitates a dissociation of what is learned in the game from how society values that which is learned. Doing so creates a common plane on which both educational and entertainment games can be assessed. The work described here is part of a larger body of work still in progress which examines commercially and critically successful video games as though they had been intentionally designed for learning. As was stated earlier, at least some digital games made primarily for entertainment already incorporate components necessary to meet the requirements of sound instruction. Since this incorporation has not been a deliberate game design decision, it is unlikely that designers such as Sid Meier or Sir Peter Molyneux would have included "implement Gagne's nine events of instruction" as part of their design specifications when creating *Civilization III* (Meier, S., 2001) or *Black and White* (Molyneux, P., 2001). Further, because this actualization was spontaneous, interviewing or otherwise studying the games designers themselves is unlikely to generate results in a form that can be applied to instructional design. Consequently uncovering the mechanisms that support learning in digital games must be approached from a different angle. Through this perspective, it is possible to identify and classify inherent learning elements found in commercial games and from there to associate the mechanisms and strategies that are employed to facilitate that learning. The ultimate outcome of this work will be to describe how the existing strategies used to promote learning in commercial video games can also be used in the design of digital games for education. The two games examined in this study represent a proof of concept for the approach.

The approach adopted in this study is a variation on reverse engineering as defined by Chikofsky and Cross (1990). Chikofsky and Cross define it as a "process of analyzing a subject system with two goals in mind: 1) to identify the system's components and their interrelationships; and, 2) to create representations of the system in another form or at a higher level of abstraction" (ibid. p.15). The process of reverse engineering seeks to recapture the original specifications of an object by examining the finished product. Typically, when applied to physical artifacts, as for example a fighter jet part, there is a known set of procedures and the goal is to understand the existing part or to manufacture others like it or that will work with it (US_Army, 2006). When applied to software, the usual goal is to re-engineer the software. Reverse engineering software does not require access to the original source code, although that makes the job much easier. What is required for a black box reverse engineering analysis is an ability to experience the behaviour of the application, and in the case of this study, that is also all that is necessary. In this case however, rather than trying to recapture the actual original design specifications and implementation details, the intent is to 'pretend' that the commercial game is an educational one, and to identify and classify the learning objectives that emerge when examined in this way along with the mechanisms used in the game that facilitate achievement of those objectives.

The two primary questions that need to be answered for this study are: "What do people need to learn in the game in order to get to the end?" and "How are people helped to learn what they need in order to win?". To answer those questions the design must be viewed through the lens of instructional design, and from that perspective the things that need to be learned in order to win the game could be referred to as the learning objectives. At the very least, they can be recognized as learning requirements. Seen in this way, the game can be seen to implement various strategies to help people achieve these objectives, as well as providing various forms of assessment to help the player determine if she has succeeded.

Game Descriptions

Both games in this study are of the same genre: they are two dimensional side scrolling platform games. This implies that movement within the game is left or right, with the possibility of jumping up to a higher horizontal level or down to a lower one. The action is essentially determined by a mapping onto a two dimensional grid, with occasional moves from the current "world" into another (defined by a different grid). Game control is similar in both games, with equivalent controls on both the PC keyboard and game console. Movement control in both games is accomplished with the left <- or right -> arrows. On the PC keyboard this is done with the arrow keys, and on the console the +Control pad is used. Both allow the avatar to jump with the up arrow. *The New Super Mario Bros.* (*NSMB*, or *Mario*) is a console game and so uses the + Control Pad, while *Math Blaster* is a PC game and uses the keyboard.

The New Super Mario Bros.

Most games have some sort of story associated with them, and *Mario* is no different. According to the story, Mario is out for a walk with Princess Peach. In the background, a castle appears to come under attack and Mario runs over to investigate. While he is distracted, we see Bowser (the villain) grab and run off with the princess. Our task is to get her back.

Game control in *Mario* uses three of the four directional keys. In addition to those shared by *MathBlaster*, *NSMB* allows for a 'bash' move (which is a landing with force) and a "dash" (moving fast), which allows Mario to run fast and crash through enemies, or if in Fire Mario mode, shoot fireballs. One action such as pressing the B-button will have varying effects depending on where in the game it is used: among other things, it allows Mario to flip panels, hit fences, and when he is Fire Mario he can use it to hurl fireballs. As is typical of many games, even though there are only very few buttons and button combinations used, they will have different effects in different contexts.

The main objective of the game is to reach the final castle in the last world in order to defeat Bowser and free the princess. This game has a total of 80 levels or courses, divided unevenly among eight sub-groups called Worlds, but it is not necessary to complete all of them in order to get to the end (Sallee, M. R., 2006). Each world has a different look and feel – for example one is dessert while another is covered in snow. Each level has numerous similarities with the others and a few differences both in terms of environments and challenges. The nature of the "terrain" is somewhat different in each level although there are connecting themes within the levels of any given world. For example one is made up primarily of mushroom-like platforms that sometimes sway where Mario must be made to jump from one to the next. Another has similar mushroom-like platforms but most of these behave like trampolines. Each level takes advantage of skills learned in the previous level as well as introducing a need to learn new ones. There are star coins to be collected, places where you can acquire power-ups, the occasional mega-mushroom, and of course points and lives to be gained.

This form of game most resembles an obstacle course, where participants must reach the end while collecting as many 'treasures' as possible and at the same time avoiding various hazards. In essential structure, it is the same as the next game.

Math Blaster: Master The Basics

In this story we are told that "evil robots have taken over because humans have forgotten how to control them" (Skelley, J., 2005). Humans have forgotten how to do math, and you, as a member of the 'Blaster Team' have been called upon to fight the bad guys and make the galaxy safe. Somehow, the evil robots are preventing humans from remembering math – except you, who seem to remember at least parts of it. Your task is to conquer the robots and regain control.

Many of the controls are the same as in *Mario* with some allowances made for the difference in platform between the two games: *Mario* is a console game and *Math Blaster* is a PC game. For example, the space bar is used in *Math Blaster* to shoot as opposed to the 'A' button in *Mario*. However the essential game play elements are the same. *MathBlaster* also has various levels, but it has several different kinds of levels. Each chase level requires the player to answer two equations correctly. *Math Blaster* offers far fewer options than *Mario* – when on a chase level players can run right or left, jump, and shoot. On the other hand, mouse control is used in some sections of *MathBlaster* where the player must click on a right answer or move numbers from one place to another. *Mario* lacks this option.

Although the primary *stated* objective within the game is to fight bad guys and make the galaxy safe, the *advertised* objectives are: "From addition and subtraction to multiplication and division, children will build confidence, speed and accuracy in basic math skills that will stay with them long after their mission is complete." ("Math Blaster Main Page," 2005).

Game Play Experience

The New Super Mario Bros.

In each world there is a map that shows where Mario is which is in the current world, which world it is, and where random power ups are. Each possible destination is marked by a coloured dot: different coloured dots on the map mean different things. When the game is first started players only have access to part of the first world, and other parts of the map as well as other worlds open up as the player gains points and wins coins. With the exception of the ‘Toad Houses’, all levels remain accessible once opened for the duration of the game.

The version of Mario that was examined was built for the Nintendo DS handheld console, so the display consists of two screens, both small (256 x 192 pixels). The lower screen has a touch sensitive surface which is rarely used in this game. Most of the counts and status variables are displayed on the lower screen but a few key values such as the coin count and time left are displayed on the top screen which is the active screen in this game that shows Mario in his current environment. Although the exact location of the information may change from one world to the next, certain “statistics” are visible to the player at all times, such as the point score, number of lives Mario has remaining, time left for his course, available power-ups, Mario’s position on the course, and the number of coins collected. Players are also told which level they are on. The graphical display is cartoon-like and very colourful, but the background is sparse and often indistinct. Lines are smooth and colours are bright. Mario and a few of the main characters appear in 3-D, but their animation is limited. There is very little talk in the game – most of the auditory feedback is in the form of sound effects and onomatopoeia.

Each individual course behaves exactly the same way each time you enter it (except for the random power-ups) – right down to when and where the various villains appear. There are limited save points (places where you can save your game), but a new one becomes available each time a new part of the map is opened up. This happens whenever a “boss” battle is won in a Tower or Castle course, and any time you open a Mushroom House using the star coins you have collected. Beyond that, if Mario makes it past the half-way point on any one course then that is where he will re-enter should he loose a life and have to try again. That feature only remains possible so long as no other course is entered between tries.

In order to succeed at this game, players must learn many different skills. They must learn to jump between two platforms of various kinds, break through blocks to get points and power-ups, to avoid or neutralize enemies such as Bowser, Koopas, and Boos (oh my). There are various problems and puzzles to solve, most of which involve finding ways to obtain some desirable object. Other than fairly general puzzle and problem solving strategies, *Mario* seems devoid of educational value. It is, by most standards, both fun and engaging.

Math Blaster: Master the Basics

This game is organized in a somewhat different fashion than Mario, and rather than a static set of levels and world-maps that the player may visit and re-visit at will, it forces the player to step through a pre-ordered set of levels that is the same for each of the eight possible ‘fact families’. The ‘chase level’ is similar in kind to *Mario*’s levels, but there are five other activities that are different.

The only display that is visible during active play is the playing field currently surrounding Blaster. There does not seem to be a way to “look around”. While there is a shield in the lower left corner showing the amount of shield energy left (equivalent to a life in *Mario*), it is the only display variable visible during play. The imagery is intended to be less cartoon-like than *Mario* but many of the objects look unfinished. Lines are jagged and graphical artifacts are common. Blasting an iceberg causes it to break up into various polygons, but when finished, the iceberg remains in its original form even though Blaster can now run through it. Icebergs also appear in parts of the course that seem to be interior sections. In others where one gets the impression we are outdoors, the trees that sometimes block our path look disturbingly like the icebergs. They are coloured green and brown rather than white and blue, but fall apart in exactly the same way as the icebergs when blasted. The overall impression is one of clumsiness and a lack of attention to the visual aesthetics. The fact that these flaws are so obvious causes them to be distracting.

At the start of the game players must choose one of eight problem sets (half involving addition & subtraction and half involving multiplication & division) before being shown the beginning of the back story. There are six different kinds of activities: Chase Levels, Combination Lock Rooms, Control Room Challenge, Launcher Control Panel, Space Cycle, and the Satellite Showdown. All activities involve choosing the appropriate number or equation from among several possibilities. After choosing the problem set, players have no further choice over which activities to complete, or in which order. On chase levels, Blaster enters from one doorway and must run along the path while avoiding robots and other bad guys. There are occasional hurdles to jump, shields to avoid (which will retract if we wait), and icebergs to blast. Each "course" behaves the same way, except for the expression to be solved. Some courses have highly repetitive elements and path segments which have the effect of giving the impression the player is going in circles. It appears that the player must get a certain number of equations correct in order to leave a course, so if one answers incorrectly, the course is longer than it is if one answers all questions correctly. It was not possible to find out how many equations needed to be answered without actually going through the course and counting how many right answers it took to get out. The documentation merely states, "Get past the obstacles and answer enough questions, and you'll open the door to the next area."

On the positive side, *Math Blaster* has many more save points than *Mario* does. When a player quits, the game is saved at the latest completed course. However, most of the rest of the game is quite inflexible and repetitive: all obstacles except the robots are stopped or destroyed with a single blast regardless of size. As a general rule, correct answers are easier to hit than incorrect ones, and in places where players have a choice of answers to a problem, there are no more than four numbers to choose from. For example, in the Control Room Challenge the player is presented with a number and shown four equations, two of which are correct. The player must shoot the correct answers and it turns out that the area around the correct answers that registers a "hit" is larger than the area around the incorrect answers. In the Chase Levels, each time you pass a goal post you are given a new equation and immediately shown two possible answers. The answers begin to move along the course almost immediately, and if the player hesitates they will move out of view and not be visible again until they reach the platform where Blaster must decide which number to run through to indicate his choice.

The game tends to be choppy, often with long (several seconds) delays between sections and levels. On the running course players must total ten correct answers in order to leave the level, but any three incorrect answers will deplete the 'Stealth Shield' and cause the player to have to begin the course again. The first time the player's shield is depleted we are told that Amy, our artificial intelligence guide has managed to slow down the robots so we may have more time to solve the problems. Unfortunately, we are told exactly the same thing no matter what the actual reason for our failure. When the author went through the course at the fastest possible speed (there is only one forward speed), but chose three incorrect answers in a row, Amy's response was the same. Second and subsequent failures bring players back to the start of the course, but without comment or explanation. The player is put back at the beginning of the course and must try again. There does not seem to be a way out except through choosing correct answers or quitting. While testing the game the author was able to repeat the same course more than twenty times before giving up.

Math Blaster has some puzzle and problem solving requirements that are similar to those of *Mario*. In the Combination Lock rooms, players must collect enough phrases (positive or negative numbers) to match the result of the presented equation. Finding the numbers presents several challenges, including jumping between platforms and avoiding minor obstacles. However, it was found that the numbers change from time to time, and the author found it highly frustrating to finally make it to the place where a needed number was only to find that the number had changed to something else.

Results and Analysis

What kind of learning is evident in these games and how does the design of the game facilitate learning? Even though both games are quite simple in structure and there were in fact few learning requirements the author still found considerable differences in how the two games supported the player/learner. Much of what needs to be learned in order to complete the game lies in the psychomotor domain, and to a lesser extent in the first half of Bloom's cognitive domain (knowledge, comprehension, and application). Players need to learn the keyboard controls, how to jump and shoot, how to avoid or defeat bad guys, and so on.

The primary mode of learning in both games is through trial and error. Neither game offers much in the way of hints or suggestions to help players when they get stuck. *Mario* is timed but there is sufficient time allowed to permit some exploration and backtracking. *Math Blaster* does not appear to be timed (there is no visible clock, and leaving the computer idle while in the middle of a course seems to have no effect), but the comments from the game give the impression that it is (we are asked to complete tasks as quickly as possible, and if we fail at the Chase Level we are told that Amy has slowed the robots down for us). There are however four important differences between the two games which fall into the following categories: 1) 'game' versus 'learning' elements (Aldrich, C., 2004), 2) the level of feedback, 3) the game's responses to attempts at action, and 4) the amount of choice afforded to the player. The latter three will be explained later in this section. The first is discussed next.

In *Mario* the both stated and apparent game objectives agree: the overall goal is to save the princess, and this is accomplished by working one's way through the levels and worlds. We are even shown glimpses of the princess. For example, when a Tower or Castle is completed, we see Bowser, princess in hand, scurry from the Tower to the Castle. *Math Blaster* has a similar set of objectives (make the galaxy safe), which is also accomplished by working one's way through various levels. We are given more of the story in between each set of activities. However, *Math Blaster* has an additional set of both major and minor objectives (the learning elements) which relate to practicing math skills. To that end, this game provides a 'Progress Screen' that displays each player's progress on seven skills, such as 'Mental Math', 'Find Equivalents', 'Problem Solving', etc. The number of attempts, mastery, and the last completion date are the statistics that are displayed on this screen. In support of those objectives, the 'game guide' lists the math skills "taught"[3] in each of the eight sections of the game. Unfortunately none of the documentation available offers any explanation of which game actions contribute to which listed skills making it virtually impossible to target specific objectives through specific game actions, or to identify which actions were done well and which were not. In other words, players are assessed but given no means of connecting that assessment to their actions.

Most of the learning requirements in *Mario* are primarily functional or skills based: there is problem-solving in so far as it assists the player in making it to the end of the level with as many points, lives and star coins as possible. The star coins are always placed in locations that require some additional action such as breaking through a barrier, and they are not always obvious during a 'standard' run through a course. Accessing various items or parts of the course are the main problems to be solved and a certain amount of strategizing is necessary to complete the challenges. This game does not include any need to remember facts like the fact families of *Math Blaster* but neither are the individual actions needed to win the game linked in any obvious way to the overall goal. Many are quite arbitrary. For example, it is not necessary to win any star coins in order to complete a course, yet there are three hidden on each level for a total of 240 coins. These coins are useful only for opening Mushroom Houses which in turn will give you a new save point. The only other purpose for the Mushroom Houses is to provide you with a way to acquire more lives. There are also other ways to increase the number of lives available to Mario (called 1UPs), yet these do not help the player get closer to the primary goal, they merely allow the player more chances to try. Also, rewards are given for completing certain tasks not necessary to win, such as collecting all of the star coins.

If the required tasks within each game are examined, the relevance of many actions within both games bears little or no relation to the overall goals. In other words both games are more similar in structure to an obstacle course than to a detective mystery. In that sense the lack of 'connectedness' of the expressions in Math Blaster to the overall story does not make it distinct from Mario, as the collection of star coins has little obvious connection to the overall goal of rescuing Princess Peach in Mario. Solving the expressions in Math Blaster could be viewed as simply some of the varied obstacles that make up the course. Contrary to popular complaints (Gee, J. P., 2005; Prensky, M., 2006), for Math Blaster the lack of integration of the learning and game elements as defined by Clark Aldrich (2004) are not detractors. This is further backed up by a study involving middle school students who were asked to critique educational games created by other students, Rieber, et. al. found that important game characteristics for the students included story, challenge, and competition, but did not include integration of storyline with educational content or production values.(Rieber, L. P., Davis, J., Matzko, M., & Grant, M., 2001) Perhaps the genre of the game is a key element in determining which characteristics are most important in any given game. Integration of learning elements in a game are not important in obstacle-course style games.

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[3] The term "taught" is used here because that is the word used in the documentation, although the author was unable to find any evidence of actual facilitation in learning the fact families beyond practice.

The *things players need to learn in order to play and win* have many commonalities in the two games and only a few differences. *Mario* players need to learn how to jump in such a way as to land in a desired position, how to break blocks both above and below, collect power-ups, defeat or avoid enemies, and so on. *Math Blaster* players also need to learn how to jump to land in a desired position, but one of the differences is that in *Math Blaster* the moving platforms tend to move faster than they do in *Mario* and that increases the need for repeated attempts. This can add to the level of frustration of the player without offering any discernable gain. Both games have various different 'worlds', but even though the format is highly predictable (each world has several courses) the activities and challenges in *Mario*'s worlds tend to be quite varied, whereas those in *Math Blaster* only look different – there are typically only one or two activities found in each set of levels. There is less variety and virtually no choice about the order. *Math Blaster* of course also includes a need for players to be able to add, subtract, multiply, and divide in a fairly wide range of ways. The primary mode of learning in both games, namely trail and error, is also employed here, as no hints are offered, regardless of how many times the player gets an answer wrong. It is possible to succeed at the game by learning to strategize and guess well. Players are able to try as often as necessary to succeed and all responses are essentially multiple choice so it is not strictly necessary to learn how to solve the mathematical equations in order to complete the game.

As has already been mentioned, there are obvious differences between the two games in the quality of the graphics and animation, the richness of the environments, and the flow of play, none of which will be discussed at length here. They are important elements in the design of games both for entertainment and for education, but they have been discussed before (de Castell, S. & Jenson, J., 2005; Gee, J. P., 2003; Prensky, M., 2006; Squire, K., Jenkins, H., Holland, W., Miller, H., O'Driscoll, A., Tan, K. P., & Todd, K., 2003). While many educational games suffer from a lack of funding, given the standing of the publisher and the longevity of this game, *Math Blaster* does not suffer the same disadvantage. Given the considerable resources available to the company that published *Math Blaster* and the length of time that the game as been in existence, and therefore available for improvement, the differences in quality between it and a game built for two 256 x 192[4] screens are harder to excuse. *Mario* offers no additional 'story' beyond the brief introduction at the start of the game, whereas *Math Blaster* plays a two and a half minute audio description accompanied by a series of still images which tells a relatively elaborate story and introduces various characters, some of which never appear elsewhere in the game. This 'slide-show' does not include any text (many commercial titles offer only text and allow users to page through them at their own pace) and can be viewed or skipped entirely. At various places in the game, players are offered more of this story, typically in 2-3 minute clips. In *Mario* there is a brief story that is easy to retain as a goal, whereas in *Math Blaster* the story becomes quite complex, yet it still does not manage to connect with the activities and so becomes an annoyance.

Given that the main mode of learning is through trial and error, it would stand to reason that a good game would support the player/learner in this mode. That would mean that there must be sufficient support to keep the player from feeling helpless or lost while they are trying and failing in their attempts to make it through the game. In *Mario*, this is done in three man ways: first through the status displays, second through action feedback, and third through choice. Status displays provide information about how many lives are left, how much time has passed, what kinds of power-ups are available, maps and locations, points and so on. These values are updated dynamically and are always visible. By contrast, *Math Blaster* offers only one piece of information which is the Stealth Shield level. There is no information on how many equations were right or how many are left to solve, nor is there any information letting players know where they are on the course. They are not told how close they are to finishing, and as has been stated before, there appears to be no way to determine what player actions have contributed to or detracted from the player's progress as displayed in the Progress Screen. The Progress Screen may only be viewed at the beginning. There is a textual Map Screen that tells which mission has just been completed and which one is next, but it only appears at the end of a major mission. *Mario* allows players to check most game statistics on an ongoing basis, and others in between each course at will. Status displays and instant feedback on moves are critical in giving participants in a 'learn by trial end error' environment a sense of progress and avoiding frustration.

Action feedback in *Mario* is provided for every move that interacts with any other object on the screen: Mario makes a specific sound if he collides with something, others if he tries to go somewhere he's not allowed, and so on. When first playing *Math Blaster* the author misinterpreted the instruction to find the exit and enter <return>. Since only one passageway was visible while the instructions were being given it was assumed that was the exit.

[4] Source: http://ds.gamespy.com/articles/567/567635p1.html

When Blaster tried to 'enter' the wrong place there was no feedback: the action simply did not appear to work. The author ended up trying several times before realizing that there were in fact two passageways. How simple it would have been to detect an attempt to go out the 'in-door' and comment on it, or to show an image of the exit during the explanation. Similarly, the difference in 'reaction' between correct and incorrect responses is quite subtle, and took several attempts to perceive.

The final difference involves choice. While it is clear that participants in a learning environment must be encouraged to try the entire variety of activities it is not always clear that they must be forced to work through them in a predetermined order, and it is especially clear that they should not be prevented from re-doing activities. In *Mario*, although access to worlds and even individual levels is earned through points and other achievements, once these have been attained players are allowed to go back to any previous world or level and go through them as often as desired. There are even some that are known to be helpful for gaining additional lives and power-ups. They can sometimes serve as confidence boosters when players are struggling with a particularly challenging section. For example, returning to the very first course is always permitted and since it is an easy course to complete, doing so is an easy way to re-open a Mushroom House which in turn will allow you to gain extra lives. Not only can it be nice to go back to a familiar section and do well, one can gain numerous lives which can in turn be used on attempts at more difficult worlds. In *Math Blaster* there is only one path through the worlds and courses, and it is determined by the game itself. The player has no choice. The path does not vary, and although the player may choose one of eight different problem sets, each one takes the player through exactly the same levels and sections in exactly the same order. Only the numbers change. The only way a section can be repeated once it has been completed is to restart the game and discard all previous achievements.

Future Directions

Although the games chosen were simple and involved less learning than honing of skills, it was still possible to distinguish learning elements within the games and to identify ways in which the game supports that learning. The use of *Math Blaster* as the control was at least partly a ruse: this game is highly rated by educators, but often identified as a poor example by game designers. Through the comparison of a suspected poorly designed game against a well-designed game, it was hoped that important differences could be found to explain the discrepancy. Unfortunately, the educational elements in *Math Blaster* did not have any attendant learning support mechanisms. Both games were discovered to promote learning through trial and error, and from that perspective it was easy to identify ways in which *Mario* surpassed *Math Blaster*. A 'good' game that employs trail and error must also provide sufficient choice for the player to backtrack or repeat sections as desired. Ideally the user can use this method to improve her score, or simply have some options about which order to progress through the levels. A 'good' game like this must also provide thorough and constant status as well as consistent and immediate action feedback. If the game is what amounts to a collection of puzzles of obstacle courses, then the contextuality of individual activities is much less important than these support features.

This exercise has helped to confirm that a similar but more detailed analysis of several other commercial games promises to expose further insights which will in turn help to inform instructional game design without doing so at the cost of the game itself. In the full-blown work, games will be chosen based on a combination of points assigned through ratings by game reviewers, designers, and commercial sales. Five to ten of the highest ranking commercial entertainment games from a variety of genres will be examined and their learning elements classified along with the procedures employed to support this learning. It is expected that numerous patterns of learning requirements (levels of learning) as well as learning support mechanisms will emerge from this classification.

Ultimately, it is hoped that others will add to this work by verifying results and testing the theories proposed. Effective education may involve more than sound instructional design, but it is not less than that (Crawford, D., 2004, with apologies to Kurt Guntheroth).

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