Classifying Learning Objectives in Commercial Games, Proof of Concept

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Theme: What makes a good game, and what makes a game good.

Learning to Play: Playing to Learn

Abstract

An important step towards gaining an understanding of how a particular medium can be used most effectively in education is to study its outstanding examples, regardless of their original purpose. It is assumed that "good" games already embody sound pedagogy in their designs even if that incorporation was not deliberate. The work described here is intended as a proof of concept for a larger study in progress. The following paragraphs will examine two games: one a commercial and critical success and the other designed deliberately as an educational game. The commercial game will be viewed as though it had been designed as a learning object. Through this perspective, it is possible to identify and classify built-in learning objectives and from there to associate the mechanisms and strategies employed to teach them. A significant outcome of the final work will be to describe how the existing strategies used to promote "learning objectives" in commercial video games can be used in the design of educational games. An additional outcome will be a synthesis of the core requirements for instructional design of digital games for learning.

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

- Marshall McLuhan

Introduction

An important step towards gaining an understanding of how a particular medium can be used most effectively in education is to study its outstanding examples, regardless of their original purpose. We already know that people learn from digital games (Egenfeldt-Nielsen, 2005; Prensky, 2006; Squire, 2003) even if what they learn in those games is not currently valued by society. It has also been suggested that "good" games already embody sound pedagogy in their designs even if that incorporation was not deliberate (Becker, 2006; Gee, 2003; Prensky, 2006). If teaching is defined as the facilitation of learning, then games certainly teach. Further, if "good" games already embody sound pedagogy, then "good" games presumably teach properly.

This paper reports on the results of an analysis of two games used to demonstrate a proof of concept for the methodology of the larger study. The two games are: Knowledge Adventure, Inc.'s *Math Blaster* for the PC (Davidson, 2006), and Nintendo's *New Super Mario Bros.* for the Nintendo DS (Miyamoto, 2006). These games will both be examined as though they had been designed for learning, even though only one of them actually was. Given that this first effort is intended as a proof of concept for a larger project, a game designed specifically for learning was chosen to serve as the "control".

The educational game, *Math Blaster* is one that 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 possible outcome from such a comparison is that the educational game lacks essential game qualities. Comparing the two will uncover some of these essential qualities.

What is a "Good" Game?

"Good" is a highly subjective term even in the restricted domain of digital games. Its definition differs depending on the game's purpose: educational games are generally assessed differently from entertainment games. Since it is not actually possible to equate the ratings of these two categories, the two games chosen in their respective categories were chosen because they were both highly rated by their own target audiences. It is important to note at this point that where entertainment games have just one "target" audience educational games tend to have two sometimes opposed audiences. First, there is the audience who will make purchasing decisions which includes teachers, administrators, and to some extent, parents so these reviews are the ones that are used to judge the game. The other audience consists of the people who will actually be subjected to the game, but who typically have little say over which games to use, and are not often asked for their opinions. If we restrict our examination of target audiences to those of the same age groups as the educational game, then although parents make up one of the larger buyer groups of commercial games, they tend to choose the games they buy for entertainment based on the recommendations (or pleading) of their children. In a sense then, even though the parents are likely to make the actual purchase, the choice of game is made by the end-user: the child who wishes to play it. Thus, for the entertainment game the reviews of the players are being used.

One measure of the "goodness" of a commercial game can be attained through its sales record, and thus indirectly support the claim that these games are effective at teaching users what they need to know in order to play the game. A game designed for entertainment would be unlikely to receive both critical acclaim and commercial success if it did not provide challenge, curiosity, control, and fantasy enough to satisfy a substantial demographic population. Players must feel they are making progress in order to remain engaged. That progress must be recognizable and supported within the game by elements inherent to that game, so in this way, it is possible to make the case that *good* games are effective in supporting players so they can meet the *game* objectives (Gee, 2005), even if those objectives are not recognized as educational or indeed even as learning objectives. They are, at the very least achievement objectives. In order to make top sales lists, a game would have to be sufficiently satisfying for the players in order for them to recommend the game to their friends. As of August 27, 2006, The New Super Mario Bros. was listed as the 9th best selling game on amazon.com, and one of only two *not* released in the current month. While marketing can account for initial release sales, it cannot sustain them.

The Chosen Games

The work described here is part of a larger body of work still in progress which will examine commercially and critically successful video games as though they had been intentionally designed for learning. Through this perspective, it is possible to identify and classify inherent learning elements 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.

In this preliminary work, *Super Mario* was chosen an older entertainment "classic". It was chosen because of its generally high ratings and popularity[1]. In addition, an older game was chosen because these tend to be simpler in design than current games, allowing for a relatively comprehensive evaluation in a fairly compact domain. Older games also involve smaller production budgets, and contain fewer "bells and whistles", which tend to put them closer on par with many existing educational games. 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, 1990) and makes virtually no use of the touch screen during game play. Also, the small-screen format of the DS is more restrictive than a regular console game, thus keeping it closer in line with what is generally seen in educational games.

The educational game chosen was Knowledge Adventure, Inc.'s *Math Blaster: Master the Basics*. The Math Blaster Series was chosen because it is a highly recognized title – most of the teachers the author has spoken to recognize this title even if they have little or no experience with educational games. The *Math Blaster* series is claimed to have won awards (although I couldn't find out which ones) as well as claiming a solid reputation for helping children learn and practice math facts (see reviews in appendix). 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.

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. Based on the definition of education as being both deliberate and value-laden, the question of whether and if so what kind of education is embodied in games is one that can not appropriately be addressed here. One difficulty is that most commercial games do not lend themselves to analysis as educational learning objects because they were never designed as such. In order to analyze 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 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:

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

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 involves examining a finished product in order to recapture the original specifications. 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 goal is to be able to re-engineer the software. It is not necessary to have access to the original source, although that makes the job much easier. All that is necessary 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 game is an educational one, and to identify and classify the learning objectives that emerge when examined in this way along with any identifiable mechanisms used in the game that facilitate achievement of those objectives.

One possible but unlikely outcome is that no elements will be found in these games that can be described in terms relevant to education. The reason this is unlikely is that games are currently being used for education and training with considerable success. Military educators around the globe as well as corporate trainers and educators have been using games, first traditional and now digital for some time and are convinced of their value (Dill & Doppelt, 1963; Ham IV, 2004). A more likely and the expected outcome is that several identifiable categories or levels of learning will come to be identified through this examination. Some possible examples include:

- functional skills needed to work the game controls;
- facts (content), like characters' names;
- main game goal and sub-goals: for each level in the game, for the entire game, and for game genres
- some games will have affective objectives (like: flicking villagers over the cliff is bad because it makes your creature turn evil)

The categories used to classify the learning in the subject games are based on Bloom's taxonomy (Bloom, 1964). Typically, in experimental situations, it helps to keep as many dimensions as possible within known domains, thus although it has not yet been proven that Bloom's is the best taxonomy to use when examining learning in digital games, it has the advantage of being well known and well accepted generally. Although in many cases the original designers of the games being examined are accessible, it was decided not to interview them directly. This approach was deemed inappropriate at this point because most of the games to be examined were not designed as educational objects, nor by designers trained in education. The processes employed are entertainment and game design processes, and the original designers of these games would not have framed their designs for an educational domain. The game designers almost certainly have different terminology for this (quests, tasks, missions, etc.) than an instructional designer would so asking the game creators directly won't generate the information in the form that is usable for the intended purposes. Similarly, interviewing players is unlikely to yield the form of response needed without leading the participants. However, both approaches have the potential to yield useful information after the fact, which could serve to validate the approach.

It is expected that numerous patterns will emerge from this classification that will be useful in the design of games for learning. 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 will appear 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 are side scrolling platform games which 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 2-dimensional, with occasional moves from the current "world" into another. Movement control in both games is accomplished with the left **<-** or right **->** arrows (arrow keys on the PC keyboard, or +Control pad on the console, and 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 (Mb)* is a PC game and uses the keyboard.

The New Super Mario Bros.

Basic Premise

Mario is out for a walk with Princess Peach. In the background, the castle appears to come under attack and Mario runs over to investigate. While he is distracted, we see Bowser grab and run off with the princess. Our task is to get her back.

Game Control

Mario uses three of the four directional keys In addition to those shared by *Mb*, *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.

Primary and Secondary Objectives

The main objective of the game is to reach to 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 among eight sub-groups called Worlds, but it is not necessary to complete all of them (Sallee, 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. 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 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

Basic Premise

Here we are told that "evil robots have taken over because humans have forgotten how to control them" (Skelley, 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. Our task is to conquer the robots and regain control.

Game Control

Many of the controls are the same 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. 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. Mouse control is used in some sections where the player must click on a right answer or move numbers from one place to another. *Mario* lacks this option.

Primary and Secondary Objectives

Although the primary *stated* objective in 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.

Worlds:

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.

Display:

The version of *Mario* that was examined was built for the Nintendo DS handheld, so the display consists of two screen, both small. 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 showing Marion in the 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 remaining, time left, 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.

Behaviour & Game Play:

Each course behaves exactly the same way each time you enter it (except for the random power-ups) – right down to when the various villains appear. There are limited save points (places where you can save your game). A new one becomes available each time a new part of the map is opened up. Beyond that, if Mario makes it past the half-way point on any one course then that is where he will 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.

Learning Requirements:

In order to succeed at this game, player 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

Worlds:

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 'fact families'. The 'chase level' is similar in kind to *Mario*'s levels, but the other five activities are different.

Display:

The only display that is visible is the playing field currently surrounding Blaster. While there is a shield in the lower left corner showing the amount of shield energy left, 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 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 undervaluing the visual esthetics.

Behaviour & Game Play:

At the start of the game players are asked to choose one of eight 'fact families', before being shown the beginning of the back story. 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, so if one answers incorrectly, the course is longer than it is if one answers all questions correctly.

Math Blaster has many more save points than *Mario* does. When a player quits, the game is saved at the latest completed course. However, all obstacles except the robots are stopped or destroyed with a single blast regardless of size. As a general rule, correct answers seem 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. 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.

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. Three incorrect answers will deplete the 'Stealth Shield' and cause the player 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. 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 repeated the same course more than twenty times before giving up.

Learning Requirements:

There are some puzzle and problem solving requirements 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? Both games are relatively simplistic so one would not expect much depth in terms of learning requirements, and indeed the foregoing analysis has uncovered few surprises. Much of what needs to be learned lies in the psychomotor domain, and to a lesser extent in the first half of Bloom's cognitive domain (knowledge, comprehension, and application). However, given the simple nature of the games, an extensive analysis using this taxonomy turned out to be more complicated than what was necessary to derive the conclusions.

The primary mode of learning in both games is through trial and error, as 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, but the comments from the game give the impression that it is. There are however four important differences between the two games: 1) 'game' versus 'learning' elements (Aldrich, 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.

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. *Math Blaster* has a similar set of objectives (make the galaxy safe), which is also accomplished by working one's way through various levels. 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. The 'game guide' lists the math skills "taught"[2] 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 game actions, or to identify which actions were done well and which were not.

Mario includes several kinds of learning that 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. They are also 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. 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. There are 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.

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[2] 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.

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. In this game at least, and it is suggested that this could hold true for all games of this genre, the lack of integration of the learning and game elements (Aldrich, 2004) are not detractors.

In term of *things players need to learn in order to play and win*, both games have many similarities and only a few differences. *Mario* players need to learn how to jump to land in a desired position, how to break blocks, 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 the moving platforms tend to move faster than they do in *Mario*, increasing the need for repeated attempts. Both have various different 'worlds', but 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. *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.

There are obvious differences in the quality of the graphics and animation, the richness of the environments, and the flow of play, none of which will be considered as important results here, as they have been discussed before (de Castell & Jenson, 2005; Gee, 2003; Prensky, 2006; Squire et al., 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 that however, the differences in quality between it and a game built for a 256 x 192[3] screen 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.

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. There must be sufficient support to keep the player from feeling helpless or lost. 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, maps, points and so on. These are updated dynamically and are always visible. By contrast, *Math Blaster* offers only one piece of information: 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. The Progress Screen may only be viewed at the beginning. There is a textual Map

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

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.

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. 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.

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.

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 prescribed 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. 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 fact families, 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, 2004, with apologies to Kurt Guntheroth)

Appendix

Game Ratings for the *New Super Mario Bros.* (Moby Games: http://www.mobygames.com/game/nintendo-ds/new-super-mario-bros)

Video Game Critic	10 Jun 2006	A+ out of A+	100
GameSpy	15 Mai 2006	★★★★★	100
Fragland.net	09 Aug 2006	94 out of 100	94
Game Informer Magazine	Jul, 2006	9.25 out of 10	92
PAL Gaming Network (PALGN)	03 Jun 2006	9 out of 10	90
GameDaily	07 Mai 2006	★★★★⯪	90
GameSpot	16 Mai 2006	9 out of 10	90
Planet GameCube	16 Mai 2006	9 out of 10	90
1UP	15 Mai 2006	8 out of 10	80
Maxim Magazine	2006	★★★★⯪	80

Review comments for *Math Blaster*:

Common Sense Media: [rating 4/5] For the past 20 years, the Math Blaster series of software has taught kids math facts by engaging them in fast-paced arcade games. MATH BLASTER: MASTER THE BASICS, the newest in the series for kids ages 6 to 12, doesn't deviate much from this popular format. It still delivers math practice in a fast-paced setting, but its look and feel have been upgraded to reflect the current video game culture.

….

Math Blaster: Master the Basics puts drilling math facts into a gaming format that will intrigue this generation of video game-playing kids. Families playing the game should pay attention to which math level they select, so that the game will drill the math facts that the child needs to practice. (http://www.commonsensemedia.org/game-reviews/Math-Blaster-Master-Basics.html)

PC Magazine: [rating 4/5] Math Blaster's updated graphics give real energy and excitement to math drills, as players guide the hero to the right answers while avoiding perils. As the title states, this is purely drills on math basics for 6- to 12-year olds, so don't buy it for your

own numbers prodigy. Still, its various challenges will make learning fun for those who need a little extra help. (http://www.pcmag.com/article2/0,1759,1917219,00.asp)

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Image Credits

Math Blaster: All images captured from author's licensed copy of *Math Blaster: Master the Basics*

New Super Mario Bros.: Images from ign.com and gamespy.com screenshots are watermarked. All unmarked images come from gamespot.com.

References

Aldrich, C. (2004). *Simulations and the Future of Learning: An Innovative (and Perhaps Revolutionary) Approach to e-Learning* (Hardcover ed.): John Wiley & Sons Canada, Ltd.

Becker, K. (2006). Pedagogy in Commercial Video Games. In D. Gibson, C. Aldrich & M. Prensky (Eds.), *Games and Simulations in Online Learning: Research and Development Frameworks*: dea Group Inc.

Bloom, B. S. (1964). *Taxonomy of educational objectives; the classification of educational goals, by a committee of college and university examiners*. New York,: D. McKay.

Chikofsky, E., J., & Cross, J. H., II;. (1990). Reverse engineering and design recovery: a taxonomy. *Software, IEEE, 7*(1), 13 - 17.

Crawford, D. (2004). Forum: No Scientific Discipline Was Ever Built on a Myth. *Communications of the ACM, 47*(9), 11-13.

 Davidson, J. *(Designer),* (2006) *Math Blaster: Master The Basics* [PC Game, PC] Knowledge Adventure, Inc.

de Castell, S., & Jenson, J. (2005). Videogames and Digital Game Play — The N ew Field of Educational Game Studies. *Orbit, 35*(1).

Dill, W. R., & Doppelt, N. (1963). The Acquisition of Experience in a Complex Management Game. *Management Science, 10*(1), 30-46.

Egenfeldt-Nielsen, S. (2005). *Beyond Eductainment: Exploring the Educational Potentia of Computer Games.* Unpublished PhD, IT University Copenhagen, Copenhagen.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy* (1st ed.). New York: Palgrave Macmillan.

Gee, J. P. (2005). Learning by Design: Good Video Games as Learning Machines. *E-Learning, 2*(1).

Ham IV, W. T., Chief Journalist. (2004, 8/11/2004). CNO Invites Leaders from Industry, Academia to Join Navy's Revolution in Training.

Math Blaster Main Page. (2005). Retrieved Sept 01, 2006, from http://www.mathblaster.com/default.aspx

 Miyamoto, S. *(Designer),* H. Yamauchi *(Producer)* (1990) *Super Mario Bros. 3* [Console Game, NES] Nintendo.

 Miyamoto, S. *(Designer),* T. Tezuka *(Producer)* (2006) *New Super Mario Bros.* [Handheld Game, Nintendo DS] Nintendo.

Peters, R. S. (1966). Criteria of Education. In *Ethics and Education*: Allen and Unwin.

Prensky, M. (2006). *Don't Bother Me Mom I'm Learning!* : Continuum

Sallee, M. R. (2006). *New Super Mario Bros. Game Guide*. Retrieved Sept 13 2006.

Skelley, J. (2005). Math Blaster – Master the Basics Documentation: Knowledge Adventure, Inc.

Squire, K. (2003). *Replaying History: Learning World History through playing Civilization III.* Unpublished Doctor of Philosophy, Indiana University.

Squire, K., Jenkins, H., Holland, W., Miller, H., O'Driscoll, A., Tan, K. P., et al. (2003). Design Principles of Next-Generation Digital Gaming for Education. *Educational Technology, 43*(5), 17-23.

US_Army. (2006). *Department of Defense Handbook: US Army Reverse Engineering Handbook (Guidelines and Procedures)*: US Department of Defense.