# The Magic Bullet: A Tool for Assessing and Evaluating Learning Potential in Games

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## ABSTRACT

*This paper outlines a simple and effective model that can be used to evaluate and design educational digital games. It also facilitates the formulation of strategies for using existing games in learning contexts. The model categorizes game goals and learning objectives into one or more of four possible categories. An overview of the model is provided and the four categories are defined. The model is used to analyze several games. The implications that this model has for the design and use of games as instructional technologies are then described.*

*Keywords:* *Digital Games, Educational Technology, Electronic Learning (E-Learning), Game Analysis, Game-Based Learning, Instructional Design, Virtual Learning*

## INTRODUCTION

We have been using media to augment and enhance learning interventions since our very beginnings. Stories, among the oldest instructional technologies known to man, came to life around the campfire with the skillful use of the teller's voice, sound effects, body movements and sometimes props and firelight – in other words, using an early form of communication media. Ever since we started to examine learning in a more formal way we have struggled to find effective ways to assess the value and efficacy of the technologies we use to deliver instruction. Many of the methodologies we employ look at the learner (Dick, Carey, & Carey, 2001; Pirnay-Dummer, Ifenthaler, & Spector, 2010; Sims, 2006), and this is very important, but as the design of instructional objects becomes more complicated and more expensive, it also becomes important to have ways of evaluating the object itself. It is useful to be able to assess a learning object while it is still in the design stages, and with more and more ready-made objects available it is useful to have a methodology that can be used to create the short list of candidates when one is trying to choose among many options. Although there is no shortage of resources on how to design and build digital educational applications, approaches to evaluation of the same are far less plentiful (Schleyer & Johnson, 2003). This is especially true of interactive objects.

Videogames are among the most highly interactive digital media currently known, and this sets them apart from other media. In fact, games are distinct from all other digital and mass media. They share qualities with many other media forms to be sure, but they also have

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other qualities that set them apart (Egenfeldt-Nielsen, 2004). A key aspect of games is that people proceed in games by doing things, and this experiential quality lies at the very core of game design. A game is not a game if there is no interaction – in other words the environment must change as a result of player actions, and videogames are popular precisely because of the experience they provide. Games designed for learning can do no less. Thus, any epistemology of games for learning must begin with the experience (Squire, 2006).

Formative and summative evaluation of instructional materials are essential elements of the instructional design process, but when it comes to software and especially digital games and simulations, the ability to evaluate the software itself *before* it is used in a real situation is essential. Evaluations and reviews of software do exist, but they often say little about what and how the students will learn (Kafai, Franke, & Battey, 2002). This paper outlines a simple yet effective model that can be used to help in the evaluation of existing games and in the design of new digital games for educational purposes. Further, this model can help educators formulate strategies for using existing games within a learning context. The first part of this paper provides an overview and explanation of the model and the second part will use the model to analyze several popular commercial and educational digital games. Implications for game-based learning in formal settings are discussed at the conclusion.

## All (Video) Games Teach

Videogame design documents are meant to describe a game in sufficient detail so that a development team can build it (Fullerton, Swain, & Hoffman, 2008). These documents discuss the type of play, the look and feel, the narrative if one exists, and what players can do in the game. They also describe the challenges that players will have to meet and how to go from one level to the next. As players progress through the game, there are skills that they must acquire and perfect, facts they must remember, and problems they must solve. These are also described. Game designers are primarily concerned with the player's experience and the design documents are intended to describe this in as much detail as possible. But there is another way to look at games that is normally not considered by designers. The experience of playing any game always requires the player to LEARN something, and that is the perspective that is the focus of the Magic Bullet model. The model presented in this volume looks at various kinds of learning in a game from a new perspective that allows users to examine the implications of how those kinds of learning are balanced within the game. This in turn allows us to analyse the game from an educational perspective.

*Learning* and *education* are two related but distinct terms. R.S. Peters, in Criteria of Education (1966) states that it is impossible to consider education without implying some worthwhile and desirable change in the person being educated. Thus, *education* is value-laden and often culturally defined but *learning* happens all the time – it is what we humans *do*. Learning includes all possible learning that can occur (things that are useful/useless, valuable/worthless, helpful/harmful, etc.) and is the superset of *education*, which includes only that which a society deems valuable. While there is no clear and simple definition of learning, it usually includes some sort of change in behaviour or in what is known. Given that, it can be said that all games require learning, even if that learning has no use or value outside the game environment. Since most single-player games are typically designed to be self-contained, and all games require learning, then it also follows that all games must teach. They are intended to be playable by a person who is alone and without help and so there must be sufficient information within the game itself to help the player get through to the end. This has implications for understanding games in a learning context. It especially has implications for approaches we might use to evaluate games.

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The path to the end of a videogame always requires the player to learn something: new facts, new skills, new strategies, and so on. This is true of all games, even puzzle games, at least the first time they are played. When examining gameplay, one notices that a player typically finishes with a videogame when there is nothing more to be learned from it. The more there is to learn in a game, the more replayability it has. Players will sometimes go back and play through a game again and again even though they have already beaten it. When asked, players will often say they do this because there are still more things to discover – more things to explore, different endings, and so on. All of these involve learning. At the other end of the spectrum, there are some games that are what the author refers to as "Sorting & Organizing" games (such as *Tetris* and *Bejeweled*) where replayability does not rely on learning something new, but instead taps into our natural propensity to classify as a means of making sense of the world, but even these include learning at the beginning.

## Analyzing Games

There is an extensive and growing body of literature in the area of games and education. Recent reviews of the literature and extensive research reports (Becker, 2010; Ellis, Heppell, Kirriemuir, Krotoski, & McFarlane, 2006; Freitas, 2006; Kirriemuir & McFarlane, 2004; Mitchell & Savill-Smith, 2004) have described many ways in which games are being used in education, some of the advantages that have been discovered, and have outlined areas of need for further research. While most of these reports are optimistic about the value of building and using games in educational settings, finding tools we can use to evaluate and analyse games, both serious and commercial is still difficult. When designing a new game or examining an existing game commercial or otherwise for its potential in a classroom or other formal educational situation it is critical that we understand what the game is intended to teach and how the game facilitates that learning. Given the investment of time and money involved in building a game for learning, or even in adapting an entertainment game for learning purposes there is no point in making or using a game if it is not a good game, and one of the things that makes a good game good is that it supports the players' learning activities in effective ways. Many videogames already embody sound learning design principles (Becker, 2008) but there are still very few formal ways to assess and evaluate learning in games. The one described here allows us to analyze how the various learning elements in the game are balanced, which in turn has implications for how engaging a game will be and how it might be used in the classroom. The model is a simple one as simple models have the advantage of being easy to remember and to implement. It can be used to evaluate the design of a game not yet built but is also helpful in evaluating existing commercial games to uncover what type of learning that game can facilitate. Evaluating a game using this approach can also help educators to evaluate how identified learning objectives can be met with that game.

## The Magic Bullet Model

This model originally came about as a by-product of a more formal analysis of several videogames using a different methodology also developed by the author known as instructional ethology (Becker, 2007b). In the course of producing the extensive gameplay logs required by the methodology, it became apparent that all learning in and around a game could be classified into four broad categories. It is known that not all learning in a game is needed in order to win and also that sometimes learning occurs that was never intended by the designers but all learning in games can be classified as members of at least one of these four sets. They are: 1) things we CAN learn in the game, 2) things we MUST learn in order to win or get to the end, 3) things we learn as a result of playing the game but that aren't part of the game itself (collateral learning), and 4) things we learn outside the game that are helpful back in the game (external learning). Several

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visualizations of the interrelationships of these four sets were created by the author, and the final picture ended up being somewhat bullet-shaped (see Figure 1, Figure 2, Figure 3, and Figure 4 below). Thus, it earned the moniker "Magic Bullet".

The four categories of learning are as follows:

1. **Things we CAN learn.** Designers create experiences for players and in those experiences there are usually various choices with attendant rewards and consequences. This first category of learning in games includes all the elements deliberately designed by those who created the game and includes anything and everything we can learn directly from the game. This category can include learning from any domain (cognitive, psychomotor, and affective) and can include all of Bloom's categories: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson, Krathwohl, & Bloom, 2001). Learning in this category need not be related to any of the game's goals but it could be. For example, it is possible to learn how to create new items and levels in *Scribblenauts*, but the game can be won without ever doing that. In *Professor Layton and the Curious Village*, it is possible to get to the end and solve the mystery without solving all of the puzzles. This category encompasses all of the learning that can happen in the game.
2. **Things we MUST learn**. This set will almost always be a subset of the first category, and includes only those items that are *necessary* in order to win or get to the end. Some games have a fairly clear set of requirements but there is often more than one way to win a game and in these cases the MUST-Learn item must sometimes be qualified in the form of an *if-then* statement. For example, it is not possible to win in *Tetris* without learning how to move and rotate blocks so both of these items fall in the MUST Learn category. In a game like *Animal Crossing* however, there is no single win state. To describe items in this category for this game, we have to use statements such as "*If* we wish to pay off our mortgage in *Animal Crossing then* we MUST learn how to earn 'bells'." Further, planting fruit trees and selling the fruit is one way to accomplish the goal of earning bells in this game, but it is not strictly necessary as there are also other ways to earn bells so planting trees falls under the CAN-Learn category for this goal. However, if the goal is to collect all possible forms of fruit, then 'how to plant fruit trees' falls under the MUST Learn category.
3. **Collateral Learning**. This category includes emergent behaviors and other things we can learn that are not part of the game and that *do not impact on our success in the game*. One could argue whether or not this should be seen as a category distinct from Things-We-CAN-Learn but here it is treated as distinct from in-game learning because it is not part of the game itself. These are not necessarily designed into the game at all, although sometimes designers may hope that players choose to take these up. For example, *Tekken* is a martial arts fighting game featuring a form of martial art called capoeira. As a direct result of playing this game, players may be motivated to research and learn about capoeira, which is a Brazilian form started by slaves that combines dance, aerobics and music with kicking. Learning about capoeira will not affect one's success in the game and is not directly connected with the game so this kind of learning would be considered collateral learning. Similarly, one of the activities players can perform in *Animal Crossing* is fishing. The fish in the game are all fish that exist in real life, and when examined in the inventory or viewed in the museum, players are presented with some facts about those species of fish, such as their size. Most of these facts have nothing to do with the game and so the facts would fall under the CAN Learn category but if

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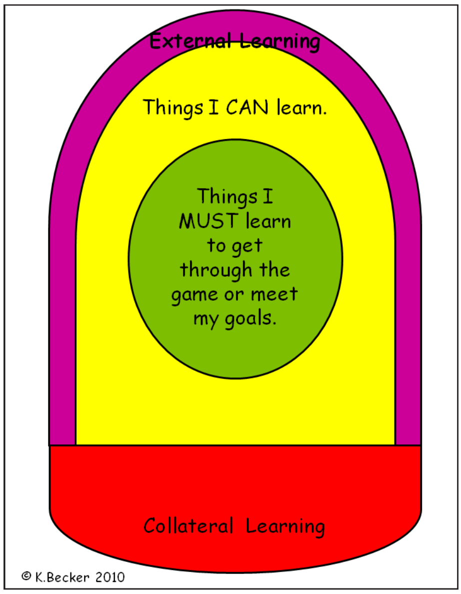
*Figure 1. The Magic Bullet, © K.Becker*




we then Google those fish and learn more about them, it is collateral learning.

4. **External Learning** – Distinct from the previous category, this last category includes learning that *can impact on our success in the game* but that happens entirely outside of the game in places like fan sites and other social venues. This category also includes game 'cheats'. Cheats are elements included in the game by the developers for the purposes of testing the game during development. They allow players to do things like skip levels or become invincible. Cheats were originally designed into the game for testing purposes, and are often left in the game once it ships. Although they are deliberate design elements on the part of the designers, they are not really considered part of the normal gameplay. Note that some game designers may consciously put the cheats into play by assuming people will use them and designing accordingly but they are rarely, if ever, required to win, so they are almost never part of what we MUST learn. For many people, a game like the original *Myst* can not be won without turning to game guides that include spoilers.

With these four elements it is possible to create a visual representation of all of the learning in a game and then consider that learning in terms of the relative proportions each represents. The categories are broad and there is a temptation to define various sub-categories in order to better classify the myriad forms of learning that we formally know about, but that temptation should be resisted. The greater the complexity, the harder the model is to use as a tool. Merrill's Component Display Theory (Merrill, 1999a) is a case in point. The basic idea is quite useful, namely that of designing instruction by following a set of prescriptions that effectively functions like a "Chinese Menu". In other words instructional objects are sorted into columns and an intervention can be fashioned by ensuring that there are sufficient items from each column. In practice, the idea turned out to be rather complicated, and in an effort to facilitate the automation of this theory, Merrill

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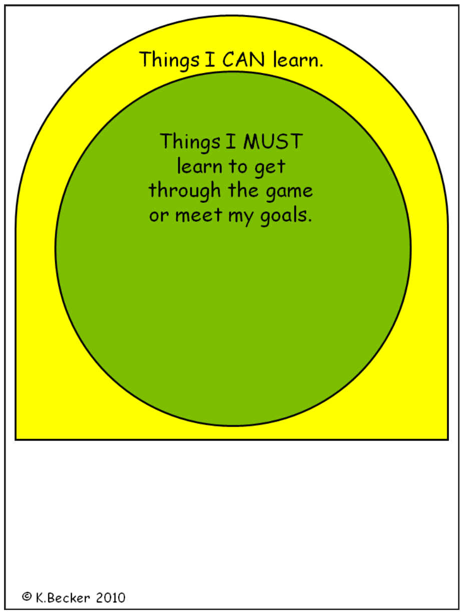
*Figure 2. No collateral learning*




produced an even more complex solution called Instructional Transaction Theory (Merrill, 1999b). The author wishes to prevent a similar progression here by preserving the simplicity of the Magic Bullet model and allowing those who use it to add whatever embellishments they deem necessary.

## Variations on a Theme

This model is highly flexible and is intended to provide a visual representation of the relative proportions of the four categories of learning in a game. The visual representation offers an easy way to understand embedded instructional strategies in a game, and to compare those to other video games. This model is primarily intended as a tool to help developers make more informed decisions about their game designs and to help educators evaluate games and game designs with an educational purpose. Different proportions of these categories will result in very different experiences in terms of gameplay, which in turn result in different learning experiences. To illustrate this, several variations of the model are shown below and each is explained and accompanied by an example of one or more games that fit the image shown.

While it would be counter productive to use too fine a granularity when mapping out the learning balance of a game, the model as it stands results in many variations that can be used to inform game design. The author does not recommend that the reader attempt to enumerate all possible learning outcomes in a given game. With the possible exception of some short-form games, it is not clear that this is even possible in many games as it would involve a thorough exploration of every playable option and every available path. Producing a partial list is a useful exercise however, and in the process items should be categorized into one or more of the four sets. Some games include games within games (mini-games) and these should be listed as single items wherever possible. If necessary, separate lists can be generated for the mini-games. Once this is done, it is possible to create a Magic Bullet image of the game. The combination of lists and images are then used

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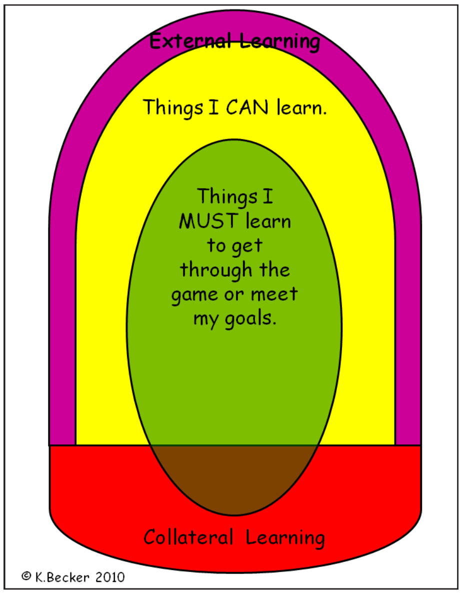
Figure 3. MUST learn includes collateral learning




to analyze the game's design and determine if this game will serve its intended purpose.

It should be noted that deciding on the exact proportions depicted for any given game is a subjective process and as a result, it should always be open for discussion. This feature makes this model both useful and unique: variations in the proportions as seen by several analyzers can inspire useful conversations about what is in the game and how that fits in with the goals of the players and the context in which it will be used.

Figure 1 is the original conception of a well balanced game. What a player MUST learn is less than half of what can be learned, but is still a reasonable amount. There exist opportunities both for both collateral and external learning. This model depicts a game that allows for exploratory play both inside and outside of the game. The model implies a richness of experience that often translates into many hours of play.

Examples of popular entertainment games in this category would include: *Black and White*, the *Nancy Drew* series, *Half-Life*, and the *Zelda* series. Note that it does not indicate the game's suitability for educational applications. If one were to use this model to analyse potential candidates for a particular learning application, it is assumed that the list of possible games would have been already filtered to ensure that the genre and subject matter are appropriate for the setting and intended audience.

In the configuration shown in Figure 2 there is no collateral or external learning at all, which could imply that this game offers little connection to any real-world activities, situations, or experiences. The lack of collateral learning opportunities in such a design implies that the game is either a single-purpose game (which could still be a good game if it is a mini-game), or an impoverished one. Very few, if any popular games could be described with this version of the Magic Bullet. A game such as *The New Super Mario Bros.* (NSMB) might possibly fall into this category, but only if one disregards cheats and the learning that is transferable to other platform games. Timing is a skill that would fall under the MUST-Learn category in *NSMB*. How much of this would be transferable to situations outside of the game would require analysis of a different sort than can be obtained from this model alone.

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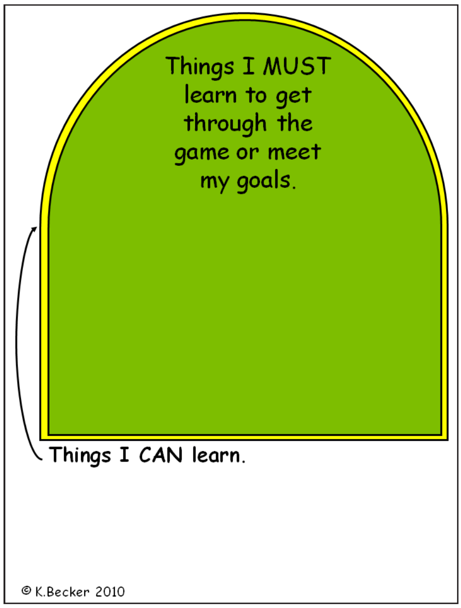
*Figure 4. MUST Learn = CAN Learn*




Some games that have the learning profile shown in Figure 2 can still be engaging, and therefore this design can still make for a worthwhile educational game, but the design must be very carefully considered and aspects that contribute to a compelling entertainment game can't always be co-opted for use in an educational game. Many 'classic' arcade games such as *Space Invaders*, or *Pac Man* would qualify for this category.

Though not originally designed as an educational game, *Where in the World is Carmen Sandiego?* has been categorized as a game for learning, and it can be described very nicely using the version of the Magic Bullet illustrated in Figure 3. This game actually requires collateral learning as part of the MUST-Learn group. When a game is designed that requires collateral learning in order to win, it must be clear that the target audience has the ability to acquire that learning. *Carmen Sandiego* had that. At the height of the game's popularity in the mid-80's, players would often complain that they didn't know enough geography to get good at the game.

This kind of scenario is highly desirable for educators but such a game will only work if appropriate opportunities to gather the requisite collateral learning are provided and if appropriate support is provided to teachers so that they find it easy to access and use the game. This is also a design that works best for a game intended to be used over numerous sessions - perhaps throughout an entire unit or even over several years.

Games as depicted by the variation shown in Figure 4 are ones where there is really nothing to learn that isn't part of the goal. They are often classified as 'bad' games by players. Sadly, many 'edutainment' games fall into this category. One of the games that many teachers recognize and perceive as a 'good' game is in fact one of these games, namely, *MathBlaster*. The author performed a detailed comparison of *MathBlaster* and *The New Super Mario Brothers* and though both games are side-scrolling platformers where the challenges have little to do with the story, one is a member of one of the most popular series of all time, and the other is the game that many game industry profes-

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sionals 'love to hate' (Becker, 2007a). These two games are described in more detail in the example analysis below.

This version of the Bullet is a more extreme variant of the distribution shown in Figure 2, and would only work as a good game if the game is a short-form game that is either not intended to be replayed (such as *September 12*), or that includes a considerable random component (such as *Tetris*).

## Example 1: A Simple Example: Chicktionary: Farm Fresh Goodness

The Magic Bullet can be illustrated using a simple game as an example. *Chicktionary* is a freely available online spelling game where players are given seven letters and the objective is to find as many words as possible using the seven letters given. As the name suggests, the game is chicken themed, with each letter shown written on a hen who produces an egg with the same letter on it when the user clicks on her. In this game, as in many short form puzzle games, the set of Can-Learn items and the set of Must-Learn items are essentially the same, so this game would be represented using Figure 4 above. Among the Must-Learn items are all the basic game controls, and in this game they are simple and well labeled. This also happens to be an example of a good learning game as the learning goals are thoroughly integrated into the Can-Learn and Must-Learn categories of the game. Unlike the next example, in this game it is virtually impossible to win by using a random choice strategy, but there are also many aspects of this game that make it fun and entertaining that are not highlighted by the model described here. The same is true of most games, so the Magic Bullet should not be the only tool used to assess a game. It is clear from this example that there can be no single 'correct' Magic Bullet configuration. The Magic Bullet configuration must be considered in context which includes the game's genre and style as well as its target audience and intended use. However, knowing the 'learning profile' of a game gives us an important mechanism for discussing game design in a learning application.

## Example 2: The New Super Mario Bros. VS Mathblaster

Another way to use the Magic Bullet model is as a means to compare games. The two games used here are members of the same genre, namely, 2 dimensional side-scrolling platform games and both are essentially variations on the traditional obstacle race. Each level consists of a series of obstacle courses where players are to reach the end within a certain time limit while collecting as many 'treasures' as possible and at the same time avoiding various hazards. Both games are produced by for-profit companies with sizable budgets. They are both intended for general audiences but that is essentially where the similarities end - they have had very different reviews and have been received very differently by their respective audiences. *The New Super Mario Bros. (NSMB)* is a purely commercial title and a member of one of the most popular series of all time. It has very little educational potential, while *MathBlaster* was specifically designed as an educational title for use in the home and in schools. *MathBlaster* is often cited as a favorite example of a good educational game by teachers and parents (though rarely by the children who are to learn from it), and yet it is a commonly used example of a *bad* educational game by professional game designers.

The author conducted a detailed comparison of both games in a previous study where it was found that *MathBlaster* lacked some of the basic requirements for an engaging game (Becker, 2007a) and the Magic Bullet model can be used to corroborate those findings. When we enumerate the learning in both games the differences become clear. The complete list is rather long, so a summary is provided here.

Both games have basic controls that would be considered Must-Learn items, but *NSMB* also has various other moves that Mario can make, some of which are Must-Learn items on some game levels and some of which, while helpful, are not necessary to win. *MathBlaster*

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has no moves beyond those necessary to win. In *NSMB* one can learn the 'geography' of the game world and levels and the game provides maps for the player, though none of these are necessary to win which makes them Can-Learn items. *MathBlaster* does not provide any maps. In *NSMB* we can learn about the power-ups and how to collect and use them but we could complete many levels without them. *MathBlaster* does not provide any power-ups.

In both games it is necessary to perfect one's timing in order to get through making that a Must-Learn item. *MathBlaster* is designed to be an educational game and among its objectives are educational items. One would assume that at least some of the Must-Learn items in an educational game would include the advertised educational objectives, but it turns out that most of the math questions in this game use a multiple choice format and many ask the

*Figure 5 Chicktionary (© K.Becker)*

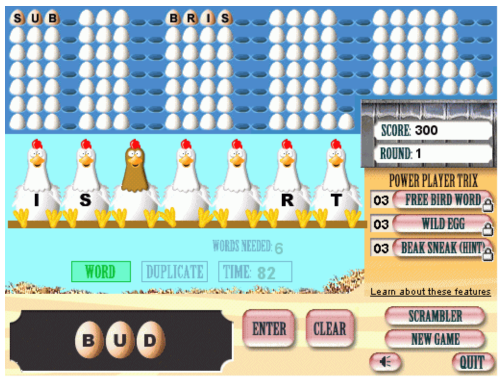


*Figure 6. Math Blaster learning profile*

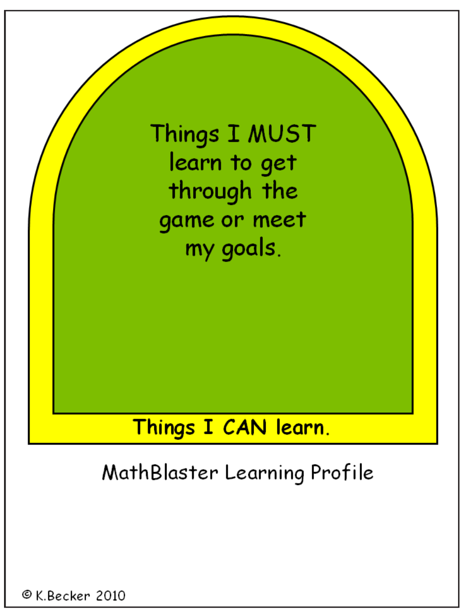


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*Figure 7. New Super Mario Bros. learning profile*

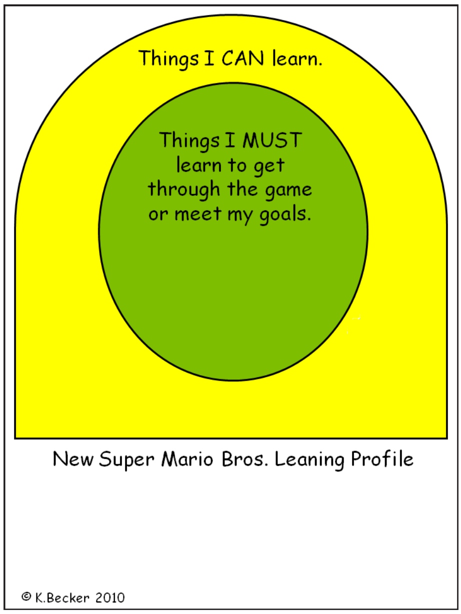
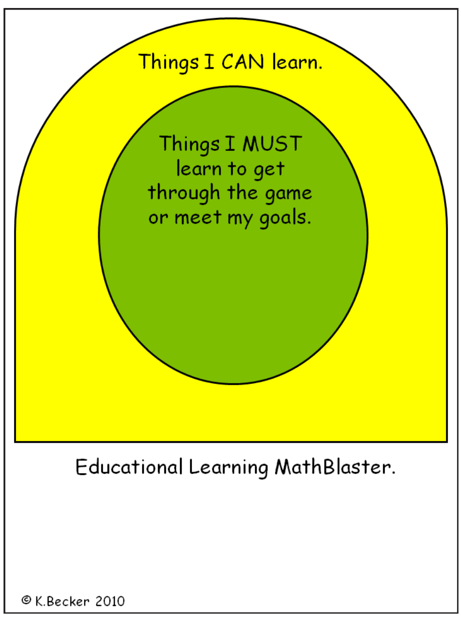



*Figure 8. Educational learning profile of Math Blaster*

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player to choose between only two options and players get immediate feedback as to whether or not their choice was correct. Furthermore, on any given level the same questions are presented in the same order. This means that it is entirely possible to get through these levels by employing the strategy of random selection alone, and with only two choices, the user does not have much to remember on second and subsequent tries. In other challenges where the player must 'shoot' the right answer, random choice still works, and in the challenge that requires the user to collect a sum by capturing numbers it is possible to collect numbers in order and then try each one till one is found that opens the door. This really only requires knowing how to count. The core learning objectives of an educational game should be in the Must-Learn category, and this is not the case in *MathBlaster*. In fact, the majority of the items that are only in the Can-Learn category are educational ones.

From the analysis of *MathBlaster* it becomes clear that it lacks the necessary balance in overall learning and does not meet its educational goals. In other words, it fails both as a learning object and as a game.

## CONCLUSION

In spite of countless attempts, we have still not succeeded in finding a single model, method, theory, or other prescription that can guarantee 'good', or successful novels, films, games, instruction, or any other creative design effort. This model does not change that. The author makes no claims that this model can guarantee success either in the design of a game or in the design of an intervention that uses a game. It does however provide an easy to use, flexible framework through which to view games, and thereby provides a structure that allows games and designs to be compared against each other. It allows for a more deliberate design and analysis that can help to ensure that the learning in a game is in fact related to the educational objectives of the intervention where it is used. It can be used to assess candidate digital games to see if they're even worthy of further analysis. The model can be used to generate learning profiles of proposed designs, and evaluate the potential of non-educational commercial games. The learning profile generated as a result of the analysis provides a simple high-level view of how the things we can learn from the game are balanced, and with that we can decide how best to support learners when they use it.

The process of generating the list of 'things learned' and classifying them into Can-Learn, Must-Learn, Collateral Learning, and External Learning is simple enough to be highly flexible yet structured enough to result in a thorough analysis. The idea of using games as learning objects is very attractive. However without a thorough analysis of the tool it is difficult to take full advantage of the medium

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