Constraints and Challenges in Designing Digital Games for Learning

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Abstract: Many educators ponder the attraction of video and computer games and wish that students spent their time in school with the same level of intensity and concentration. Is it possible to take what works in video games and translate that to education? Some educators hope that any educational experience that occurs on a computer will somehow capture that magic. Some design games that adopt conventions and production values of popular game design, but with educational content.

This paper evaluates attempts to harness the lure of these games for educational purposes. It offers an analysis of why the nature of video and computer games is antithetical to traditional forms of school curriculum, content and assessment. Finally, it discusses the market forces that make educational games rare.

While current efforts to invent new educational games have made inroads, these efforts have been mainly in defense, business training, and advertising. Currently, research grants and non-profits have funded games that provide game-like experiences in academic areas. However, for educational games to go mainstream, there will need to be a source of funding that comes directly from the purchase of the games themselves, just like television, books, or textbooks. Understanding market forces, both in the school and home markets, may help future educational games get published.

Keywords: Classroom-based learning, Classroom of tomorrow, Informal learning, Learning and playing, Simulation

1. Why make digital games for education?

Many educators envy students’ attraction to video and computer games and wonder if it is possible to harness the power of video games in education. Some hope that any educational experience that occurs on a computer will somehow capture that magic. Some design games that adopt conventions and production values of popular game design, but with merged educational content.
There is no doubt that video and computer games have positive educational outcomes for the users. In an in-depth literature review, Alice Mitchell and Carol Savill-Smith conclude that there is “…the use of such games can stimulate the enjoyment, motivation and engagement of users, aiding recall and information retrieval, and can also encourage the development of various social and cognitive skills.” (Mitchell & Savill-Smith 2004).

Many of these studies look at social and behavioural impacts found after video and computer game playing. Some investigate the relationship between academic performance and video game playing. Often, these studies conclude with predictions that such games could be designed to be more closely connected to academic subjects.

For this paper, “Video games” are games designed for a specific hardware console or handheld game such as Nintendo Wii and GameBoy, Microsoft X-box, Sony PlayStation2, PSP, and others. “Computer games” are designed for use on personal computers, either by running application software on the computer or playing a game on a website on the Internet.

This paper, written by an educator who also designed video games as well as computer software for the home and school markets, evaluates attempts to harness the lure of these games for educational purposes. It offers an analysis of why the nature of video and computer games is antithetical to traditional forms of school curriculum, content and assessment. Finally, it discusses the market forces that make educational games so rare.

While current efforts to invent new educational games have made inroads, these efforts have been mainly in defense, business training, and advertising. (Squire, 2005) Currently, research grants and non-profits have funded games that provide game-like experiences in academic areas. However, for serious educational games to go mainstream, there will need to be a source of funding that comes directly from the purchase of the games themselves, just like television, books, or textbooks.

1.1 Why are games an attractive model for education?

When educators look at video and computer game players, they see young people suddenly transformed into attentive learners, willing to spend inordinate personal time learning to master complex situations. These same students, however, may not devote similar dedication to school-related activities. Educators wonder what it is about these games that could be used to make students devote the same attention to the goals of school.

Educational software developers who deconstruct the elements of these games may come to the conclusion that the game play can be extracted from the context. Therefore, the thought goes, mere substitution of educational content and context while leaving game play elements untouched will produce educational games with great benefits for learners and company shareholders alike.
In engaging computer and video games, the player must master a progressively challenging set of skills to advance each step in the game progression to ultimately “win” the game. This advancement through challenges is seen as a direct correlation to advancing through a course of study. In a classroom, the teacher guides the acquisition of skills and the students are able to progressively tackle harder problems, learn new facts and produce higher quality products required by the subject. It seems obvious that if an educational game led players through a similar process, similar results would be achieved, with the added benefit that students would pay attention and be engaged more than in a traditional classroom environment.

The secret of a videogame as a teaching machine isn’t its immersive 3-D graphics, but its underlying architecture. Each level dances around the outer limits of the player’s abilities, seeking at every point to be hard enough to be just doable. In cognitive science, this is referred to as the regime of competence principle, which results in a feeling of simultaneous pleasure and frustration - a sensation as familiar to gamers as sore thumbs. (Gee 2003)

2. How and why video and computer games get made

Video and computer games are often created by devoted fans of games who either work for large corporations or small development companies. These games are then “pitched,” much like Hollywood movies, to a publisher. As the industry matures, however, “…industry has come to rely on large-scale successes and is a ‘hits’ business…” (Williams, 2002). If a publisher decides that a concept will make money, it is funded; then years of programming, marketing campaigns, and testing begin. These publishers spend millions of dollars so that these games have a chance of making millions more. In the consumer game industry, thousands of demos and concepts are pitched for every game that is funded, and there are hundreds of concepts that never make it out of pre-production and testing onto store shelves. Very much like Hollywood, it is a game of high stakes, big profits for a few winners, and many good ideas ending up on the cutting room floor.

Most computer and video game publishers rely on the retail channel to sell most of their games. Although a few games have made inroads in alternate channels, the most money is still to be made in traditional retail (Williams 2002). Therefore, for most video and computer game concepts to be even considered for development, it has to appear to be a viable “hit” for the publisher. Publishers cannot spare any money for marginally profitable projects.

Fortunately for educational games for children, there are two channels: consumer (home) and institutional (mainly K-12 schools) markets. Each of these markets delivers its products in different ways to the purchaser, and, finally, to the user (the child or student). These markets are controlled by the perceptions and
needs of the gatekeepers to the channel, then the primary purchaser of the product. In both cases, these markets are indirect—the end user is different than the purchaser. This situation tends to push publishers to fund games that appeal first to the gatekeeper (retail buyer or administrator), then to the purchaser (parent or school personnel), rather than the user.

Understanding the positions of various stakeholders in the educational game market gives insight into how these forces and attitudes impact game design.

2.1 Consumer Channel Gatekeepers – Retail Buyers and Parents

Gatekeepers are people who purchase video or computer games. In these channels, the purchaser is rarely the user of the game. When gatekeepers purchase one game over another, they influence design and development of future games. After all, no publisher wants to make a game that will not sell.

2.1.1 Retail gatekeeper – The buyer

Every retail store has a buyer responsible for software and video games. This person reviews all games, sometimes even game ideas, and responds whether they will buy the game and stock it on their store shelves.

Retail buyers tend to be representative of their retail customers in their attitudes about games and education. They are rewarded when the products they select sell well, so the software and games they look for are typically close to the products that are currently selling well. They look for games and software that have a “hook” that will attract purchasers, and for children’s games, buyers often feel that popular television shows and characters are the best indication of potential purchaser interest. Buyers now ask publishers to back up any new product with marketing research showing mass market awareness of the characters, popular trend analysis, or media ratings (movie, TV, book) before they will commit to even a potential purchase. These factors tend to reinforce similar games and discourage innovation.

In addition, since computer and video games made for a youth audience sell fewer units than those created for adults, the chance for large profit is reduced. Retailers look to the publisher to commit advertising money to make sure a product will sell, and have set figures on how much money their “shelf” is worth. Any product that cannot bring in the highest profit will be immediately replaced by one that has that potential.

2.1.2 Parents as gatekeepers for educational game choice

If an educational game does make it onto a shelf somewhere, the purchaser is likely a parent. A primary concern for most parents is that their child does well in school; educational games are a means to that end. Whether the goal is to
remediate a struggling student or give an advanced student an extra edge, success in school is at the core of many parental educational game purchase decisions.

Even though parents are not bound by strict rules about standards and assessment, they are still bound by their experience of their own schoolwork decades ago. Innovative games that support concepts such as logic or critical thinking may be overlooked in favor of games with easily recognizable school subjects. For example, parents who purchase a “math” game may feel cheated if they don’t see plus signs, equations, and traditional problem representations.

2.2 School Market

A second market for educational games is K-12 schools. Schools are under extreme pressure to meet demands for increased accountability and test scores. The content of marketable games must therefore be tied to mandated curriculum standards, which list the things that students must know in a certain grade level and vary from state to state, nation to nation. Most of these standards also envision a way to make sure that students know these things, and mandate the types of outcomes that will show that the students have mastered the content that matches these standards. The game therefore must correlate to these standards and provide assessment vehicles so that the students’ progress through these standards can be measured. Without measurable gains in specified objectives, the game will have a very limited market in schools.

The school market for educational software provides some hope for educational game designers. Since schools will pay more than consumers for software, it seems logical that there should be more money to develop good educational games. However, the hard numbers behind a potential game for schools do not justify a software publisher spending the millions of dollars necessary to produce top quality games. A successful consumer computer or video game has the potential to sell a hundred thousand or more units in a few weeks; a top selling game sold only in schools would be very fortunate to sell that many in four years. In addition, most schools have a buying cycle of 18 months to 2 years while purchases are being considered and budgets approved.

There are approximately 115,000 K-12 school buildings in the U.S. (public and private.) At normal videogame pricing, sales of 500,000 units is required to breakeven (DFC Intelligence, 2004). Even if you make the incredible assumption that every school in the U.S. is a target market, every single one of them would need to purchase 4 units of any videogame for it to just to make the publisher’s investment back.

Clearly, this is not a market that will by itself support the development and production of educational videogames. Traditional publishers, especially publicly traded ones, simply cannot tell their investors and shareholders that they choose to spend their money on something with a low, slow return on their investment when there are other choices that make more money.
2.2.1 School market impact on game design
For these reasons, even educational software companies have almost completely
turned their backs on educational games. If they still choose to sell to schools, they
are concentrating their development and sales efforts on large instructional
learning systems that can cost schools tens of thousands of dollars, even up to a
million dollars for large installations. It is obviously more efficient to make one
sale for a hundred thousand dollars than to sell a thousand units of an educational
game for less than $100 each. Inherent in the sale of these large systems is the
promise that they will cover massive amounts of content and provide assessment
data for the school system. Schools look for comprehensive “solutions” that will
give all students and teachers the same experience, reduce technical support
headaches, and provide easy to read assessment reports.

To compound the high cost of these systems, standards and assessment criteria
differ between states and between nations. These differences require expensive
customizations to the software design, a cost that the publishers pass along to
schools. All these factors drive the design of educational software for schools
towards the management of a content pool and delivery of assessment data and
away from providing compelling experiences that energize, inspire, and engage.

3. Designing educational games
The two most common types of educational games are:

- Content Drill. These games are designed so that large pools of content
can be drawn into a game-like process. A familiar game genre is
employed as a thin overlay for the action. The game elements are
intended to add fun and increase the length of interaction that the student
has with the content, rather than act as an integral part of the learning.

- Simulations. These games set up a rule-based simulation where the
player makes decisions that affect the outcome of the game. These
simulations can be very simple or complex, with rule and graphics that
vary widely. These simulations can represent reality-based situations, like
sports or historical events, or even job related activities like being in
charge of an emergency room or a real estate tycoon.

There of course are other types of games, but almost all games that are deemed
educational fall into these categories.

3.1 Drill and practice
Content focused games are the norm for education; especially ones used in school
settings where assessment needs drive both the design and the purchase. These
games, also known as “drill and practice”, and widely known in the industry as
“drill and kill”, typically have activities that users can select, either from a main selection menu, or as part of a story-driven element that is meant to inspire the user to continue the game to the end.

The nature of these activities is to present challenges that the user can solve by manipulating screen elements – dragging the element to the correct place, clicking on the correct answer, etc. These activities can then be played over and over again simply by drawing new elements from the content pool. The design of the content pool is then turned over to educational experts who can figure out how to meet as many curriculum standards as possible with this pool. The depth of the pool simply depends on the size of the development budget.

A game designer faced with the challenge of making this fun, has to then work around the content pool constraints. For example, a game may have to work with four, five and six letter words, and the game may be also translated into six different languages. The game has to be designed so that any word can be plopped into the content pool and the game will still work. There will be no opportunity to make the game actually deal with what the words mean, or to tie the content into how the game play works.

The cost of art creation also enters into the design. Art and animation are very expensive, and having unique graphics that correspond to the content may simply not be possible. Therefore the graphics that surround the content have to be neutral, and not connect to the content in any way. A typical option so that the computer response doesn’t get too boring is to have several different “reward animations” that randomly occur as the user gets the correct answer.

For example, an interesting game design working with simple sentence construction might be to actually have graphics showing different actions occurring as the user moves words around in the sentence. Arranging the words “The cow jumps over the moon” would result in one set of animations, while if the user moves the words to say, “The moon jumps over the cow” would result in another. However, if a designer is supposed to create a game where the student is exposed to 1,000 nouns, the resulting exponential number of graphics needed would make this interesting design impossible for financial reasons alone.

Schools are increasingly required to show how every investment reflects back to improved student achievement on standardized tests and is correlated to state curriculum standards. In response, educational games have added assessment to games so that as the game is played, the computer can keep track of progress and achievement. Computers are very good at counting things, so that tends to be the mode of assessment added to educational games. How many “right” answers, how long a user plays a particular activity (“time on task”), and other quantifiable elements end up controlling the game design and discourage innovation.

At one of the most successful educational software companies, the president was known to have a mandate that “there are no wrong answers” allowed by the games. This mandate solves a lot of design questions, but is horribly constraining on game play. It eliminates any potential questions from parents or teachers that the software might show the student an “incorrect” answer such as a moon
jumping over a cow, and makes assessment easier. After all, the sentence is correctly constructed; it just isn’t the sentence the content expert expected the player to construct. As the president of this company correctly judged, it is easier and cheaper to constrain the user than it is to design an intelligent assessment system that can handle unexpected answers.

Educational software designed to teach and assess sentence construction would therefore prohibit such “playing” with language in order to teach specific concepts. However, linguists have long known that children construct language by “messing about” with language. Tongue twisters, jokes, riddles, limericks and puns are all part of this. Software that limits playful aspects and focuses on specific skills removes agency from the player and eliminates several critical elements of what makes games fun.

Content-driven educational games also get motivation wrong. The rewards are superficial and extrinsic. Successful answers generate a reward animation or screen with a congratulatory message. In successful video games, the reward for success is more power, more control and more knowledge that is essential to the continuation of play. The sense of accomplishment inspires an eagerness and ability to learn more.

What is best about the best games is that they draw kids into some very hard learning. Did you ever hear a game advertised as being easy? What is worst about school curriculum is the fragmentation of knowledge into little pieces. This is supposed to make learning easy, but often ends up depriving knowledge of personal meaning and making it boring. Ask a few kids: the reason most don’t like school is not that the work is too hard, but that it is utterly boring. Papert, Easy Doesn’t Do It.

The larger problem with these games is that they aren’t fun. They may (or may not, depending on the research you read) increase standardized test scores, but they aren’t something that a student will devote time and energy to voluntarily like a video game. Some educational games go to great efforts to substitute the made-up worlds of video games with realistic educational worlds built to reproduce curriculum content. However most educational games focus on low-level topics of simple literacy and arithmetic. The analytical rigor, ingenuity and passion reserved for the most popular video games are seldom invoked by educational computer games.

Finally, drilling students does not teach anything. These games assume prior knowledge of whatever subject they are drilling, from times tables to phonics. At best, these games present some instructional text before the game begins, and then let the student know when they are right or wrong. The software can count the number of times the student is correct and incorrect. Any awareness of how to help the student learn new subjects, or understand why they are missing problems is typically too expensive to implement and diminishes the time left to deliver more content. In fact, computer systems capable of teaching complex concepts
may be elusive. It is hard to imagine that a student who has not learned a concept in an environment created by a competent professional educator, will be taught successfully by an educational software package.

3.2 Simulation games

Simulation games appear to offer more layered opportunities for educational content and in-depth explorative learning. Historical simulations, war games, city building simulations, and other more realistic games have even been very successful in the consumer software market. Educational support materials, such as teacher guides and off-computer activities, for some commercial games have even been developed and used in schools. Simulation games allow the player to access worlds that would be impossible, too costly or dangerous to experience in reality (Mitchell 2004). Several simulation games have been developed specifically for the purpose of teaching, especially in the area of business, finance and knowledge management.

Successful educational simulations tend to fall into the job-training or vocational education category, where computer simulations can provide very valuable lessons to students about job requirements and the specific skills they need to master. This can be especially useful for jobs with dangerous elements or that require the use of equipment that is easy to simulate. Simulator training has long been an essential requirement for pilots and similar jobs.

Simulations can provide a user with engaging, open-ended experiences that offers many opportunities for learning in context. However, the pressure on schools to connect every student experience with curriculum standards and content undermines the use of simulations that allow exploration and demand time for immersion in the simulated world. Exploratory activities do not deliver the surety that the content has been “covered” and are more difficult to assess. Simple assessments demand that students respond with simple answers, ones they are not likely to gain in playing a game. If an assessment is going to test students on what the names are of the 5 major rivers of Brazil, it would be a waste of time to spend hours or days on a realistic simulation game set in the Amazon. For simulations to be useful in a classroom, the assessment must be as complex as the game.

Realistically, however, even if assessment and time pressures were removed, simulations can only provide learning opportunities that are fully defined by the game designers. Experiences with unknown outcomes do not lend themselves to simulations. At the other extreme, simulations intended to faithfully recreate historically accurate events suffer from being too constrained. A simulation of World War 2 has to allow for Germany to win the war. If that can’t happen, the user will quickly find that they are not able to significantly impact the game play and will be bored. Schools tend to have an issue with a game that purports to teach history if the history can come out differently for each player.
It can be very difficult to design a simulation that is both engaging and accurate. The popular computer game, Spore, for example, designed by the expert game designer Will Wright, is advertised as being a realistic simulation of evolutionary biology. Yet scientists have rated the game as failing to accurately convey even the most basic information about science and biology. (Bohanon 2008)

Using simulation games in classrooms allows students to find ways to play the game successfully using a wide variety of strategies and tactics. Some students learn the obvious game rules and may indeed gain insight into a historical event or a process such as running a city. However, some students will learn how to win the game by making allies with other students, finding logical holes in the game play or logic to exploit, or other strategies that do not result in any learning of the intended “content” of the game. (Squires 2005) While these may be useful social strategies, or even show more ingenuity than actually playing the game as expected, this makes it even less likely that games will be used in classrooms where the assessment is based on content knowledge.

4. Games for learning: games for schooling

Most parents are concerned that their child does well in school, and educational games are a means to that end. Whether the goal is to remediate a struggling student or give an advanced student an extra edge, success in school is at the core of most educational game purchase decisions. Parents look for educational games that match their child’s perceived need, and they use the vocabulary of school to make that decision. A bad grade in spelling will mean a spelling game, a parent who wants their child taking algebra next year will look for a game that promises to teach algebra. It is the rare parent indeed who takes the logical leap from bad grade in math to purchasing a chess tutor.

Many parents however, are quite willing to purchase games that look fun, and and will acknowledged that their children learn a lot from games such as chess tutors, logic puzzles, or historical simulations. The contradiction comes, however, when these games are touted as educational. Neither parents nor children believe that anything fun will be helpful to the child’s success in school. This dichotomy between schooling and learning is prevalent in parents and children of all ages. The edutainment industry amplifies this tension.

In addition, parents make a subtle distinction between computer games and video games. Parents universally perceive video games as a recreational “break” for their children, and will not purchase video games labeled as educational. Parents have more variability when the computer is involved, as they see the computer as intrinsically educational. Most often, their purchase of computer software for their children is based on what they perceive as a balance of fun and education.
5. Conclusion

Educationally meaningful computer and video games will require substantial shifts in attitudes towards education in the school, consumer and designer community. It’s not as easy as plugging school curriculum into a game engine. In addition, success (meaning significant sales) would necessitate changes in the retail environment, changes in school assessment, and changes in parent and student expectations. None of these are trivial changes; therefore it is unlikely that educational digital games will generate enough revenue to encourage design and development. The alternative is finding non-traditional sources of funding for educational game development.

Educational games are a complex subject, with design issues, market pressures, and a wide range of user needs and perceptions to understand. These complexities, however, result in serious tension between the stated goals of making educational games engaging for students and providing content delivery and assessment engines that educational institutions, teachers and consumers will value and purchase. While making a game fun, educational game designers often find that the games do not fall into neat curriculum categories, teach mandated subject matter, or deliver as much content as the customer is demanding. The fun will always lose in this battle. If there is no customer, there is no product. This essential dilemma, with curriculum and assessment driving the design of educational software, means the fun will be sacrificed, player interest will ebb and ultimately, the educational game will have no impact on learning.

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