BRINGING GAME-BASED LEARNING TO SCALE: THE BUSINESS CHALLENGES OF SERIOUS GAMES

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The Increasing Lure of Game-Based Learning

Beginning with Jim Gee's recognition of bona fide learning processes in his and his son's video-game playing [1], and propelled to public recognition through Ben Sawyer and David Rejeski's launching of the Serious Games movement[2] and its attendant conference, the use of video games to teach academic content has now reached a level of national interest. Game-informed learning is now the basis for a new urban school serving grades 6-12 [3]; numerous colleges and universities offer game design courses [4]; engineering professional societies have launched member sections devoted to games [5]; a recent issue of *Science* magazine featured several articles on virtual-world and game-based learning [6]; foundations have recently poured millions of dollars into research on games and learning ($50M from the MacArthur Foundation alone [7]), and the venerable National Academies, as evidenced by this volume, has begun to hold workshops on the topic.

"Serious games" refers to games designed to achieve non-entertainment goals, of which education is a major subset. What has changed, other than terminology, since the edutainment days of the 1980's? Quite a bit [8] - the games themselves have become much more sophisticated: they no longer drill users on what they already know, but use embedded rules and complex, branching decision structures and narratives to teach learners what they need to know. Their learning goals require many 21st century skills: systems thinking, problem solving, information tracking and resourcing, collaborative information sharing, leadership, teamwork, communication. Serious games are also not limited to "kiddie offerings;" the content goes well into such advanced topics as numerical methods for engineers [9], medical school instruction [10], and designing computer network architectures [11]. More modern research on these newer games, though limited, supports their pedagogical effectiveness [6] [12]. Particularly fascinating are reports that immersive education can dramatically shrink the learning gap between high and low achievers in the classroom [13] [14]. And, finally these "serious games" or experiments in "immersive education" are being produced by both academic and for-profit sectors, thereby granting the field more legitimacy than before, and more interest from philanthropy and government funders.

Why Learning Games are So Hard To Find – It's Not What You Think

Presuming, for the moment, that games ***can*** teach, the question arises as to why a wildly popular medium in other spheres has not gained a greater foothold in both formal and informal education. Several initial hypotheses can be discarded almost immediately – for example, that there exist no games that teach academic subjects. Indeed there are many, ranging from games covering physics (e.g., *Crayon Physics* [15], *Physicus* [16], *Coaster Creator* [17]) to math (e.g., *DimenxianM* for algebra [18], *NIU-Torcs* for numerical methods [9]) to mechanical engineering (*Time Engineers [19]*), to network engineering (*Mind Share* [11]), to biology (*Virtual Cell [20], Cell Saver* [21]*, Immune Attack* [22]) to ecology (*Resilient Planet* [23], *River City* [24], *Quest Atlantis* [25], *Wolfquest* [26]) to many others.

A secondary hypothesis is also contraindicated: that games covering academic content, particularly math and science, are doomed in their attempts to attract an audience because the subject matter itself is so inherently dull. A living counter-example is *Whyville* [27], a virtual world populated by 5 million children [28], that offers science and math-based activities targeted to 8-14 year olds. Since *Whyville* is not formally offered through schools, this amazing population of would-be scientists is almost exclusively logging in from home in their spare time. *Whyville*, incidentally, has a dominantly female demographic and a large stickiness coefficient (average stay in-world is 30 minutes) [28]. Those learning numerical methods via *NIU-Torcs* racing car game were similarly hooked: statistical analysis showed users to be 0.82 standard deviations more "engaged" (on a personal scale of not-at-all to entirely engaged) when working with NIU-Torcs as compared to a random sampling of other times during the day [29]. And, despite the fact they spent twice as much time on the game-based homework as their colleagues in traditional textbook classes, 90% of those who had the opportunity, voluntarily elected to go on to take the advanced numerical methods class [9]. *Wolfquest*, a game about ecology and the lives of wolves, has been downloaded 300,000 times and has 10,000 players logging on daily [30].

A third hypothesis offered to explain the near-invisibility of "games that teach" is that a truly fine exemplar – one that captures all the production value of a AAA entertainment title, thereby commanding public attention and generating high profits – has yet to be built. The lack of a $100M academic game is, as far as the author knows, a true fact. Production costs for academic learning games tend to be much more modest, typically no more than $5M and most commonly under $1M ([31-34]). In his presentation, "Serious Game Production," Noah Falstein, whose commercial credits include *Star Wars: Empire at War* and *Indiana Jones: The Last Crusade*, as well as several "serious game" titles, explains what one obtains for increasing levels of development cost [35]: more scope (more game levels and story lines to explore), higher quality graphics (3D rather than 2D, higher realism, larger world or variety of places to inhabit), more extensive playtesting and production value (better software engineering for faster game response time, higher frames per second, professional sound, fewer execution bugs, more powerful physics engine – leaves flutter in the wind; items break according to resolved forces instead of stored animations). He gives the following examples to illustrate the cost hierarchy, indicating what each price point was able to buy [35]. This cost hierarchy was confirmed and further fleshed out in a separate conversation with David Martz [34] of Muzzy Lane Software. From Fahlstein's list [35]:

$5K: Example *Happy Neuron* [36] (brain teaser)
- 2D
- simple puzzle-type game (brain exercise)
- Based on a prior game's mechanics
- Less than 2 months' development time

$15K (approx): Example: *Airport Insecurity* [37] (Airport security practices[1])
- 2D
- original game design
- more complex game mechanics (game outcomes modeled on real TSA reports)
- 6 months' development time (estimated)

$200K: *Freedom Fighter 56* [38] (Hungarian revolution[2])
- 2D, detailed art
- original game design; graphic novel with embedded mini-games
- 15 months' development time

$2M: *Re-Mission* [39] (first person shooter, cancer treatment[3])
- 3D
- Detailed but not high realism graphics
- original game design
- User testing and multiple redesigns to ensure product met effectiveness benchmarks (change in patient attitudes and health)
- 18 months' development time

$10M: *Gears of War* [40] (3rd person shooter)
- 3D
- original game design

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[1] Teaches the ineffectiveness of airport security practices by modeling game outcomes on real TSA reports

[2] Teaches the circumstances, mechanics and processes of how people's revolutions arise; familiarizes the learner with the specifics of the Hungarian revolution against Russia.

[3] Familiarizes the player with the different kinds of cancer that exist, the ways these cells they infest the human body, and how different treatments work to eliminate them.

- Highly realistic graphics
- Up to 8 simultaneous players
- $10M (cheap by entertainment game standards)
- 3 years' development time

$50-$100M: *World of Warcraft* [41] (fantasy)
- 3D
- Fantasy art that spans continent-sized regions and takes years to explore
- Detailed visual effects – light filtering through trees, footprints dissolving in the beach sand, mist rising from the ground
- Tech services that respond to and support 8.5 million simultaneous users, on hundreds of different software/hardware configurations interacting with each other inside the game (as of 2009, over 10 million users)
- 5 years' development time

What is instructive about this list is the relative independence of cost from engagement – measured either in terms number of users, or hours spent. *World of Warcraft*, the most expensive game on the list, has over 10 million players currently. However, *Happy Neuron*, at an original $5K development cost, has since expanded into a suite of 35 similarly-themed quick 'n easy brain teaser games with 35 million "exercises completed" [36]. Each of its 125,000 users [42] is therefore, on average, completing 280 game exercises. Whyville is also rendered in cost-effective 2D. Its cartoon-drawn characters, some of which are no more than mere ovals, have attracted 5 million players, from a humble beginnings of $30,000 and one in-world activity [28]. Thus, for orders of magnitude lower production cost, simple Flash-based games can be very addictive, and with a profitable business model they can grow to significant size. Other familiar examples of popular games in the 2D Flash category include *Tetris* and *Bejeweled*. The converse is also true: high production value and 3D graphics do not guarantee an audience; for a list of particularly notable high end video game flops, see Ref [43]. In the opinion of Howard Phillips, a game designer with credits at Microsoft, Nintendo, LucasArts and THQ: "People will accept lower graphic quality if the game control[4] and quality of game play[5] are high." [44]

With respect to science education, many of the features that can be purchased at the tens-of-millions-of-dollars level have yet to be equated with improved learning outcomes. Characteristics that *have* been equated with improved

[4] Game control: the degree to which the user can customize his interaction with the game (for example, freedom to choose what to do next in the narrative, freedom to choose the appearance of his avatar, etc)

[5] Quality of game play: a loose term that includes everything from fast response time and bug-free software to a gripping narrative and interesting but easy-to-grasp game mechanics. However this term does not include "quality" in the academic sense of having superior pedagogical outcomes.

learning outcomes include learner control (ability to navigate through the game under one's own choice, instead of being "led along") [45] and in-game user help systems [14]. The former is also a large contributor to user engagement, as measured quantitatively in [46], and the latter is largely responsible for the exceptional learning outcomes of low achievers when they learn via game [14]. Classroom research has shown that cooperative learning improves learning outcomes by 25% over solo learning [47]; if we extend this concept to games, then multiplayer design *should* prove to produce superior learning outcomes over single player design. Note however, that none of these proven or potential learning-related features are show-stopping cost drivers. Even the most complex of these, the multiplayer structure, has already been adopted by several medium-budget commercial learning games: *DimenxianM* [18] from Tabula Digita, *Making History* [48] from Muzzy Lane Software, *Whyville* [27] from Numedeon.

And, to make the cost issue even less germane, a slew of authoring products are now becoming available to drive game development costs down further. These include *Blender* [49], a free high end graphics tool; *Multiverse* [50], a free high end game development system, used to make customized virtual worlds; DARPA's *Real World*, in which warfighters can easily create simulations of their own battleground experiences [25]; and *Torque* [51], a low-cost game engine popular in academic circles. Tools are also being created that will dilute development costs by spreading the effort among many co-developers: *Medulla* [52], being developed by the Federation of American Scientists, will enable structured multiperson collaborations on 3D environments, managing authentication, peer review, contractor payments, consumer ratings, volunteer participants and more. In yet another development, the increasing adoption of standardized file formats for 3D objects, e.g., Collada [53], will enable copy and paste across 3D environments, so that game developers are no longer faced with the cost of having to develop new graphic assets from scratch. Most of this work on free and easier-to-use game creation tools has been underway in just the past 5 years, but in aggregate, it should significantly reduce game development costs.

In conclusion, it appears it is not lack of product, or boring subject matter, or a more modest expenditure on game development that keeps learning games from attracting a significant audience. Instead, this article will propose it is a series of business-related issues: finding a sustainable business model, creating or obtaining a distribution network, and achieving consumer acceptance.

Failed Attempts at Scaling – Why The Two Obvious Approaches Did Not Work

As described below, the two obvious approaches to bringing learning games, or serious games, to a national audience have failed primarily for business reasons unrelated to lack of product, content, or initial cost. In the first approach, someone attempts to "scale up" a game developed in an academic research environment. This approach almost universally fails, for two reasons: 1) the grant on which the game was developed flatly does not provide funds for commercial hardening, marketing, sales, distribution or other functions that would be required to allow the game to be provided at commercial scale and 2) even when such funds are externally provided – as in the Department of Defense (DOD) experiment described below – the game is so poorly designed from the outset to meet these challenges, and its academic developers so unskilled at the tasks required to get the product to a level of commercial acceptability – that failure is also almost inevitable.

> "... bringing together the DoDEA [Department of Defense Educational Activity] educational community and the selected commercial providers with their research-based, newly developed educational courseware was a daunting task. A major impediment for the seamless transition from a research product (prototype) to a viable commercial product was that the initial development began with different objectives between the research and commercial communities.
>
> For example, the typical research goal was to develop a prototype, a proof of concept. not a "hardened" for classroom use, commercially ready courseware product. More importantly, developers involved in federal research programs and grants do not have the capability, personnel, or financial resources to bring these research products to a level of maturity where they are commercially ready. In many cases, they (e,g., university personnel working on grants) not only lack the technical know-how to harden their courseware, but also the skills to successfully bring their product to market. The developers in these institutions (e,g., universities and research laboratories) are not provided with incentives to produce products that are commercially viable. Furthermore, many developers in these environments are not intellectually interested in commercialization of their research." [54]

The second obvious approach – using the commercial know-how, investment capital, and leverage of a large company and pushing academic content through their existing pipeline, has also failed. Large entertainment game companies have difficulty seeing how their existing business model of enormous up-front investment, followed by mass uptake by an audience of millions in a few months following release, would work for educational offerings. In 2003, Microsoft held a Higher Education Leaders Symposium, in which it concluded that high quality educational games would be "exceedingly expensive to build with a business model geared toward a mass market of consumers" [44]. The question of "who will pay for development" weighed heavily in those proceedings, since the market Microsoft was experienced with was not the market that would buy educational games, and the obvious market of educational institutions (colleges, schools) was not seen as having deep enough pockets. Established educational software companies do exist but limit themselves to the K-6 market, an age bracket where parents still make software purchasing decisions for their kids. Even so, these companies have not been spectacularly profitable and are not in a position to take on risky investments in academically-developed software. Knowledge Adventures (KA), for example, was sold off by Vivendi for lack of profitability in comparison to Vivendi's entertainment game business, and KA is now sustained through venture funding [55].

Textbook companies, which might seem to be a natural conduit for digital education, have had difficulty adapting their business models to be compatible with game-delivered education [56] [28]. Sales of print books so dominate revenue generation, sales force training, internal incentive systems, and lobbying agendas with textbook adoption committees that it is very difficult to deliver an educational game via a textbook publishing company unless it is literally packaged onto the textbook as a "free addon." Unfortunately "free addon" is not a business model that attracts quality game developers desiring a salary, nor does it pay continued upkeep and maintenance costs. Indeed, the very model of textbook delivery is "fire and forget" [57] – a single textbook can persist for 6 years untouched [56] - compared with the need for constant maintenance, versioning, and upgrading of software offerings. Textbook companies have no workflow systems in place to provide this constant nurturing [56]. The marriage of textbook company and serious game developers has therefore faltered.

As impossible as it may seem, there is a potential third way forward. First, we have noted that the investment need not be at the tens-of-millions of dollar level, as is sometimes presumed. Secondly, while the latest Lara Croft/*Tomb Raider* game may have a market life of a few months, academic content should have a much longer tail over which to recoup revenue [56]. Algebra will no doubt be with us through next year and beyond. Thus, a financial model of up-front investment + longer-term return at slower rates should work. This is the model currently being pursued by a new crop of small developers, whose stories constitute many of the examples given in this paper: Muzzy Lane Software, 360Ed, Tabula Digita, Numedeon, and Software-Kids, to name a few. This "second wave" of serious game development is thus distinct from the initial wave, which devoted itself to one-off government grant-funded projects.

From discussions with both old and new serious game developers, the necessary up-front investment for content creation appears to be available through a variety of sources: *River City* [57] and *Immune Attack* [32] launched themselves on National Science Foundation (NSF) funding, *Dimenxian* [58] and *Peacemaker* [59, 60] relied on venture funding; *Making History* [34] and *Time Engineers* [61] were self-funded; *Re-Mission* [62] and *Virtual U.* [63] were funded by philanthropic dollars. The most unusual funding model to date is the joint partnership between 360Ed and Florida Virtual Schools, where each put up half the money required to create *Conspiracy Code* [64], and each contractually obtains a 50% royalty from product sales, regardless of which partner makes the sale. This co-funding arrangement for product development tacitly assumes there will be enough profits from game sales to give a reasonable return to both the academic and the commercial investor [33]. However, the question of "who pays" *after* the game is developed – who are the game buyers and how do we reach them? – is a thorny dilemma.

The Three Business Challenges: Sustainability, Distribution, and Customer Acceptance

Sustainability

Developing a sustainable revenue model from paying customers is one of three major dilemmas facing the scale-up of serious games, the others being distribution and customer acceptance. Economic sustainability is certainly the issue on the minds of commercial game companies that have toyed with the serious games space. It is also the major question for academic developers. Scaling up from academic origins requires a process of product hardening and ongoing maintenance that is consistent with commercial quality software production (versioning, user testing, marketing, etc). Some of the new developers are beginning to take on these functions or provide them as a service to others [33, 34]. However, they need a sustainable source of revenue to cover these recurring costs. A one-time grant, that covers only initial game development, will not suffice. Sustainability requires revenue that is tied to product use, rather than product development. Somehow, the users must pay.

Distribution

Distribution is the second major challenge faced by those wishing to bring immersive education to scale. As noted above, commercial game manufacturer and textbook companies have the needed distribution channels but do not have business models that are compatible with selling serious games. The academic researcher/game developer, by himself, has no virtually channels at all. Posting one's game on the equivalent of "myuniversity.edu/facultymember/course1201/lecturenotes/~game" is not distribution. In the absence of a significant marketing push to drive traffic to the otherwise obscure website, no one will go there. Unfortunately, marketing is a task well outside most researchers' expertise and the grants' funding allowances. Thus the establishment of new distribution channels, well suited to this new product genre, is a major challenge for expansion of the field.

Customer Acceptance

Consumer acceptance is the third challenge, after ensuring the product can be reliably sustained and actually be distributed to the customer. This article will examine several known factors relating to consumer acceptance.

These three business issues: sustainability, distribution, and consumer acceptance are, in this author's opinion, the three primary factors limiting the scaleup of immersive education to million-user levels. While these three barriers are common to all markets, they are managed differently for each. The remainder of this article will examine the specific cases of the K-12 school market and the general public/higher education markets, for these three barriers to adoption. Because purchasing authority in higher education rests with the individual professor or student, and not some central, rules-bound authority, scalability in higher education is considered similar to the general public case.

Current Approaches to Achieving Scale in K-12 Schools

Sustainability for K-12 Educational/Serious Games
The "who pays" question for K-12 serious games has been tackled in a wide number of small-scale individual experiments. The following numbered list summarizes these attempts, indicating the funding source (the "who" in "who pays"), the marketing/sales approach used, and the type of package sold. Also listed is the specific game using the described approach, with the game's company given in parentheses following. In all cases, this heretofore unpublished information comes from one-on-one interviews of serious game company officials whose cooperation is gratefully acknowledged.

I. Direct-to-Teacher approach [61] [34]
   a. Funding source: classroom supplies money, own pocket
   b. Approach: via teacher conferences, teacher websites
   c. Purchase: individual units or classroom site licenses
   d. Examples: Time Engineers (Software Kids), Making History (Muzzy Lane Software)

II. Direct-to-District approach [58] [65]
   a. Funding source: national or state program funds such as Title I, Enhancing Education Through Technology (EETT), Accelerated Math Instruction (Texas), State of NY Education Stimulus funds
   b. Approach: Instructional technologists or curriculum designers that are in charge of district-wide purchasing/implementation decisions
   c. Purchase: District-wide licenses, after major initial delay required for evaluation and discussion (12-18 months). However, licenses are lucrative (6 figures) and tend to be renewed in perpetuity (long tail). Enterprise sales model.
   d. Examples: DimenxianM (Tabula Digita)

III. Direct-to-Student approach [28]
   a. Funding source: corporate sponsorship through branded activities in the world
   b. Approach: kid-friendly articles in the LA Times (10 years ago); contest sign-up sent to home emails of children already engaged in game, challenging them to engage their class (more recently);

wholesale makeover of existing school-distributed magazine to feature game content, discussions, community
  c. Purchase: none (game is free to user)
  d. Examples: Whyville (Numedeon)

IV. Bundled with Teacher Training [65] [58] [34].
  a. Funding source: professional development funds
  b. Approach: Bundle game with in-person professional development training, when sold to multi-purchase sites. Offer in-person training above cost, use excess to partially cover cost of game.
  c. Purchase: Professional development classes or short courses
  d. Examples: None in which this is the sole method of financial support, though *Dimenxian M* (Tabula Digita) obtains part of its income stream through this approach, and several developers have noted the potential for significantly increasing revenue via this method [65] [58] [34].

V. Via 3rd Party Large Textbook Publisher [61] [56]
  a. Negative return on investment; not recommended
  b. Example: Time Engineers (Software Kids); several others [56]

VI. Via Installed Hardware Base
  a. Funding source: expansion of existing sales channels
  b. Approach: installation on student laptops
  c. Purchase: technically, none required, though use of these free games drives traffic to games-for-purchase
  d. Examples: a dozen games installed on student laptops in Maine and Michigan via Kauffman Foundation's games-to-laptops initiative

The last two approaches require some additional explanation. Item V, sales via a 3rd party large textbook publisher, typically occurs in the context of a small serious games producer entering into a contract with a large print publisher in order to be displayed in the large publisher's catalog distributed to schools. Unfortunately, the large publisher rarely has any expertise in marketing or positioning games, and few sales result. Lee Wilson, a former textbook company executive, commented, "I could list 20 companies that have gone down that route and not have it work out" [56]. If the small developer pays the large publisher an upfront fee (typically several thousand dollars [61]), rather than negotiating a cut of sales, the small game developer has put much-needed capital at risk with little hope of return.

Item VI, sales via an installed hardware base, refers to the Kauffman Foundation's Games-to-Laptops Program, which encouraged serious game developers to place older or demonstration versions of their games on the state-financed laptops distributed to middleschoolers in Maine and Michigan as part of the one-to-one laptop programs in these states. The game developers obtained free exposure (and thus potential sales for commercial variants of the same games); the students obtained free educational games to play. Since the one-to-one laptop programs in Maine and Michigan are estimated to reach 150,000 students, access via these laptops provides reach to a significant audience.

Distribution to K-12 Schools

Referring to the experiments of the intrepid game developers listed in the previous section, we see that distribution to schools can take place via teachers, students, district-level decision-makers, and even the hardware itself. However, the one commonality in all these stories is that the game developers themselves had to create the distribution paths for their product. They could not simply hand the game over to a third party that had existing distribution channels and assume it would get into the hands of the consumer. Instead of turnkey distribution – which does exist for the home market – developers who chose to deploy in schools had to create their own distribution network into the schools, one node at a time. They personally had to show up at trade shows, go to conferences, visit principals, talk to district curriculum managers, etc. The long, painful process of personally establishing a distribution network is a major reason why the appearance of serious games in schools is so slow. Ntiedo Etuk and Steven Hoy of Tabula Digita advise that it takes about 18 months to make the first sale at a district level. Wilson [66] further warns that schools have a very limited purchasing window for the year (typically May-July) so all sales have to occur in that window, or wait until the following year.

There are educational sales forces that one can hire to make door-to-door visits to schools. However, these teams are ill-equipped to sell non-traditional materials and find their commissions eaten alive by travel expenses, as they make 5-7 trips to close a single sale, as opposed to the usual 1 or 2. In the end, this approach is profitable for neither side [67] [68].

If the company has enough economic stability to survive the expenses of product hardening, user testing, marketing and sales, and if ultimately the product reaches the consumer via some distribution network, then the final hurdle is customer acceptance. Consumer acceptance in schools is far more difficult than in the home market, as we will see.

Consumer Acceptance in K-12 Schools

The attempts to cajole schools to buy educational software (through students, teachers, administrators or district officials, as described above) have encountered a number of adoption hurdles that were quite consistently described among our interviewees. These K-12 adoption challenges are also elegantly detailed in *Wilson's Best Practices for Using Games and Simulations in the Classroom* [69]. The observant reader will note that most of these challenges can be avoided through careful product design.

1. Teacher training – teacher training was seen as an absolute necessity by

virtually every company we spoke to. Perez estimated, from experience with his DOD program [54], that about 30% of the cost of deploying educational software in schools was taken up by teacher training [25]. Teacher training for serious games is currently provided in a number of ways, from purely online resources (*Time Engineers* [70]), to a mixture of online resources and in-person training (*Making History* [48], *Immune Attack* [71], *River City* [72]), to mostly in-person training (*DimenxianM* [18]). Modern webinars or "how-to" videos (not available in the era of the DOD study) were seen as nearly as effective as in-person training. From Chris Dede [57]: "We switched teacher training over to Eluminate [a webinar-based delivery system, Ed] to cut costs [over in-person training, Ed]. Teacher responses were quite high. No one complained." However, as noted earlier, teacher "professional development" funds are a fairly robust category of money that schools can use to indirectly to pay for serious game purchases, if games are bundled with in-person training [65] [58] [34]. Thus the business plan strategy may demand in-person training even when the learning goals do not require it.

2. Hardware Requirements – Educational software must fit existing hardware requirements for computers and Internet access. No unusual firewall ports should have to be opened (a major hurdle in using *Second Life* [73] in the classroom or office is getting this permission from the institution's IT officer), no video cards should be required (most student and office computers have very low grade or no video cards) and RAM requirements should be small. Several experts [34, 57] [33] [61] believe that browser-based delivery represents the future for the classroom market, because it avoids these issues. Flash, being cross-platform (Mac and PC), is a favored programming approach for the K-12 market; it yields the 2D cartoon-like graphics that play easily on most computers. However, even if the technology is nominally compatible, many schools have no more than 1-2 computers per classroom. In this case games' strength – personalized learning – is unattainable. Says Jason Project's Schutz [67]: "The full promise of 1-to-1 computing in the classroom is not yet a reality. While people assume that most classrooms are 'wired,' it is common to have no more than a couple of computers at the back of the room. Until every student has access, the fullest potential of games will not be achieved."

3. Classroom Use Patterns – any new technology is first deployed in old use patterns: computers were first used as glorified typewriters before they were used to surf the Internet. For this reason, educational games have to fit the current use patterns of schools [69]. This means the content must be modular, in increments no greater than 40 minutes and preferably less than 10; *DimenxianM* [18], *Making History* [48], *Conspiracy Code* [64] and others all adhere to modular construction. Also, the content needs to be visibly mapped to state standards and state-mandated tests, so that

teachers and administrators can justify its use [65] [58]. Teachers also demand the software be compatible with their course management systems [33] [34]: they want to see whether Suzy completed a virtual activity, and what score she got. And, finally, it helps if the software comes with lesson plans and other teacher support that indicates how it would fit into a normal class day [34].

4. Privacy – Schools are sensitive to students giving out self-identifying information. Generally speaking, the software cannot ask for such information unless the request is vetted through the teacher (e.g., teacher enters all student contact information) and is securely stored, out of reach of other potential users. For example, when Kauffman placed publicly available games on student laptops in Maine and Michigan, it discovered the games would not be allowed to ask for students' email addresses as a part of registration, even if that information were to be used for no other purpose than retrieving lost passwords.

5. Security/Safety – While browser-delivered content is the most compatible with school systems technologically, internet access in schools can trigger parent, teacher, or administrator alarms regarding online safety, consistent with the public discourse on this topic. A careful national survey of 2574 law enforcement agencies [74] shows the classic online predator to be almost entirely fictional, but the image still persists. Because the problem is mostly perception, some ways of addressing it rely on counter-perception: use of a trusted brand name, for example. *Barbiegirls.com* discovered their brand was enough to surmount otherwise significant parent concerns [75]. For added reassurance, it is possible to add functional security – place the game or virtual world on a dedicated server only students and teachers can access (e.g., servers on the Immersive Education Grid [76]); prevent navigation to sites other than those screened and whitelisted (Kajeet's cell phone for kids [77]); background-check all adults before allowing them to enter the kids' virtual space (*Second Life*'s Teen Grid [78]). *Whyville* implements a blend of controls, including requiring new users to log on three separate days, take a chat license test, and send in a parent permission slip (in return for free in-game currency). In addition, automated filters check for and flag undesirable language (including personally identifiable information), administrators check on the flags (and can reprimand or suspend players), users can notify administrators of harrassing incidents, and users can immediately set in-game tools so the harrasser becomes invisible to them [28].

6. Innate acceptance of the technology – Some individuals simply feel more comfortable with software than others. The 2007 "Speak Up" survey[79] documents that the concept of using of games in the classroom is far more appealing to teachers who self-rank high on technological familiarity, compared to those who self-rank low. However, only 6% of teachers felt

> games had no place in the classroom at all. Teachers' interest in games can be attributed to the games' perceived potential to increase student engagement and learning outcomes [79]. The perceived effectiveness of serious games is currently one of the major selling points used in marketing them [58] [65] [34].

Ntiedo Etuk, CEO of Tabula Digita, summarized the top-of-mind consumer adoption issues into these four questions, which his team is always asked when selling *Dimenxian* to schools:

1. Will it work (improve student learning outcomes)?
2. What technology will it require?
3. Will students use it?
4. How do my teachers use it? (=what professional development do you provide?)

Being able to answer these questions is an excellent starting point for new game developers.

Conclusions: Achieving Scale in K-12 Schools

The challenge of economic sustainability, distribution network, and customer acceptance are in various stages of being resolved for the K-12 use of serious games. The up-front investment required to *create* new games is not easy to find, but it is not impossible, and multiple financing models exist, from grants to venture capital. Business models that can expand that initial investment to cover consumer hardening/user testing/marketing/sales and other functions – as well as maintain the product after initial deployment – are however poorly developed. Numerous experiments at finding a paying K-12 user are in play; none so far has proven immensely profitable. To date, the number of school site licenses sold is very modest, typically in the 200-300 range per game [34] [61]. It is interesting to note that none of the game developers interviewed complained that "lack of funding" was preventing legions of otherwise eager K-12 customers from purchasing their wares. The money seemed to be there, for the modest price points of the games (typically \$9-\$25/copy, the lower figures representing site licensed copies) and the number of interested buyers. Furthermore, K-12 receptivity to digital media of all sorts was seen to be opening up further, now that several state legislatures have taken action to either allow the states' textbook funds to purchase non-print educational materials or require schools to avoid purchasing print materials in the first place: Indiana [80], Texas [81] Virginia [82], and California [83].

Distribution challenges were the primary complaint of game developers – the difficulties of getting to the customer greatly limited K-12 sales. There exist no turnkey distribution companies that function well in the educational games market; it therefore rests on the individual developers to go out and personally create those distribution networks, one node at a time. This fact dramatically slows the rate of adoption in K-12 schools.

Finally, there exist several customer acceptance hurdles for K-12 – however, these are becoming well known and can be circumvented with appropriate product design (e.g., product comes in modular format, plays in a web browser, has teacher instructional materials, is mapped to state standards, etc.)

Current Approaches to Achieving Scale with the General Public, Including Higher Education

With the exception of institutional IT hardware issues (IT officials not wanting to open unusual ports in firewalls), the issues confronting serious games in higher education have more similarity to the general public than the K-12 use case. K-12 purchasing is organized and controlled by state-sanctioned authorities, while in higher education – like the general public – it is the individual purchaser who rules. Professors dictate which learning materials they want, then order the campus bookstore to buy them; students may choose to buy what the professor recommended or something entirely different. In addition, consumer acceptance in higher education is not marred by the other K-12 barriers: small time segments (most study is during long hours outside the classroom), imposed state standards, poor computer hardware, the need for teacher training to develop technological familiarity, etc. Nevertheless, the adoption of game-based learning by higher education suffers. Serious games are not often seen in college-level courses; the exceptions tend to be games such as *NIU-Torcs* and *Virtual Cell*, which are used by the professors who developed them. We argue that to reach a wider audience in higher education, mostly what is needed is greater public exposure. In other words, games designed for higher education use will need to achieve the same kinds of economic sustainability and distribution pathways they would need for the general public use case, as described below.

Sustainability for Educational/Serious Games in the General Public Market

There are several great advantages of the general public market over the K-12 formal education market. One is, it is much, much larger and distribution is much easier. This much is evident from sales figures for game titles that have been sold via both pathways. *Time Engineers* currently has about 300 site licenses to schools; however, when sold through large stores as part of a "Middle School Success" bundle with other software, 80,000 units were purchased. Likewise, Making History has about 250 school site licenses, but Muzzy Lane was able to sell 40-50,000 copies of the consumer version of its *Making History* game direct to public. Who are these people, paying for educational games?

Parents

For titles geared to young children outside the classroom, it is the parent (specifically, the mother [84]) who buys. However, the market shrinks as the child's age goes up. Almost no home educational titles are available above grade 6, where the child begins to make his own software purchasing decisions. From the Sept. 16, 1996 edition of Discount Store News [85]:

> "The major problem in producing educational products for older kids," added Broderbund marketing manager Jennifer Apy, "is that they're independent, finicky, trendy and have very individual tastes. Up until 10 or 12, parents make the purchases, but after that, the kids take over."

Knowledge Adventure [86] now limits itself to K-2 offerings. Eve Seber [84] of Viva-Media further acknowledges children's education is a tough market, where profits are generally made through careful control of production expenses rather than large scale user purchases.

Hardware

One way around the fact that parents don't buy software for older kids is that they still buy larger ticket items for their children. Thus, pairing a game with a piece of hardware, such as a computer or cell phone, allows developers to continue accessing children through parent purchases. This was part of the motivation for Whyville's partnership with Dell [87], where Whyville will sit on Dell computers sold through Walmart. Similarly, the partnership between the Kauffman Foundation and kajeet allows Kauffman's *Sports Bytes* science and math quiz game to reside on specialty cell phones designed for kids. However, if software is paired with hardware, revenue is not obtained through software sales directly and must be recouped indirectly through either an arrangement with the hardware provider, or through interaction with the game experience itself (e.g., in-game advertising, sales of virtual goods, and the like). The revenue is not insignificant. Explains Lee Wilson [56]:

> Computer/hardware companies will frequently include software on their machines and offer vendors a small payment for this ($2-$3 or less). Given the volume they ship in it can generate enough revenue to tide things over. The marketing bump is modest since most people pay no attention to stuff provided for free - but the revenue is nothing to sneeze at. . . . The developer then gets to sell upgrades and add-ons to the people who do end up using the game.

Corporate Sponsorship

For titles targeted to kids, an alternative to the parent-pays model can be corporate sponsorship. Advertising or in-game placement of brands primes the child, who then can influence the parent's buying behavior. Done well, there is little conflict with educational objectives. The Toyota Scion activity in *Whyville* is often cited as an example: children can buy a Toyota Scion to drive around Whyville, but to do so they must learn how to make car payments. Toyota achieves brand recognition as children buy and play with their cars; the children learn financial responsibility. And, the next time the parents go car shopping, no doubt the child will at least want to *see* what a real Toyota Scion looks like. The corporate sponsorship model avoids issues related to convincing parents to buy educational software for their kids, or kids being willing to buy it for themselves.

Hobbyists, Adults

If the market for children's educational materials is so limited, who is buying the 40-80,000 copies of serious games off the shelves? The answer appears to be adults and hobbyists. *Making History*'s David Martz explains there are both history buffs and strategy game buffs who buy *Making History*. *Wolfquest*, designed for ages 9 and up, found its core demographic in wolf enthusiasts, who began posting 200-400 comments daily on the developer blog before release, downloaded the game 2000 or so times an hour on the day of release, and caused a pre-emptive shut down by *Wolquest's* "cheap, shared" web hosting service before a new server was found to take the traffic [30].

In addition to satisfying their core interests, many adults apparently also want to learn material they never quite mastered as children: the calls to Viva-Media's help line for *Physicus* featured an extraordinary number of adult players [84]. That this is a national trend is evidenced by statistics for the Nintendo DS. This popular handheld gaming device (9.95 million sold in 2008 [88]) was designed for kids, but 20% of Nintendo DS units now have adults aged 30+ as their primary player [89]. The adult players lean towards educational and self-improvement software [89]. Nintendo's Sandy Hatcher, Senior Manager for Licensed Software and Accessories, explained the adult gamer market was one of Nintendo's fastest growing market segments [89].

One of the most fascinating trends in the adult learner market is the use of games to teach material required for job certification. Cisco has been a pioneer in pairing game-based learning with certification testing. In essence: play the game, pass the test, get certified, get a job. Beginning with smaller scale offerings such as the Cisco binary game (teaches binary addition), the Cisco Learning Network now offers many mini-games and at least one game, *Mind Share,* that covers fully half the CCENT/CCNA curriculum required for Cisco certification [90]. Though offered only via Cisco's own website (and buried fairly deep within it), the market of certification-hungry learners is sufficient to generate 1,670 independent downloads of the free Mind Share demo a month and 13,400 for the free binary game [91]. The game–based curriculum covered by the full version of Mind Share is priced similarly to text and digital offerings of the same content, at $49.95 a copy; unfortunately sales figures for the priced version were not available.

<u>Untapped Markets</u>

Upon reflection, there may be untapped audiences for serious games, that are distinct from the general public/child-parent audience that has been an unsatisfying source of revenue for traditional children's software companies. According to Christensen [92], disruptive technologies emerge from niche markets that are poorly served by other solutions. In the present case, we have limited but startling evidence that well-designed learning games succeed with special needs and low achieving children, a population not well served by any other approach. If the disproportionate learning outcomes can proven without a doubt, then the special needs and low achieving student market may provide a firm and profitable foothold for serious games to begin to take over the mainstream. Such is the logic propelling Lee Wilson's company, PCI Education, which is targeting exactly this audience.

Alternatively, the other end of the extreme may also provide a niche market – the advanced learner for which all school offerings are insufficient. If one is looking for a well-heeled clientele willing to pay exceptional prices for an exceptional product, one might look to the overambitious parents of advanced learners, who could support premium versions of educational software and provide cachet to the product before sales to larger markets.

Distribution

Fortunately, distribution to the public and to higher education is much more straightforward than to K-12. There are turnkey publisher/distributors who will – once the product is completely ready for market – cover all manufacturing and marketing-related tasks: packaging, ESRB ratings, advertising, bundling with related products (often necessary to break minimum sales targets set in advance by etailers and retailers), negotiation of sales agreements with retail outlets. Because publisher/distributors bear the marketing and advertising costs, they can be an attractive option for new, cash-poor game companies. However, in exchange, the serious game developer cedes control of his product to the publisher. Profits are also typically low: about 15-20% of the game's retail profit ends up returning to the game's developer [34]. Fifty cents per game sold is not an uncommon return [61].

It is possible to hire a "pure" distributor, which does no marketing or advertising, but can inject your product into the network of stores and outlets with which it has agreements. In this case, the serious game developer must take on marketing and advertising costs himself, but he retains much more control over the product's final look and feel, as well as over profits. Different publisher/distributors and pure distributors exist for different product lines: mobile games, PC games, specific platforms (Xbox, Wii, etc). In addition, some of the serious games developers are becoming publishers of a sort: Numedeon, Muzzy Lane and Linden Lab all have an existing customer base and an online platform (*Whyville*, *Sandstone* and *Second Life*, respectively) onto which new content can be loaded. These developers can host new material on their platform, typically for a fee.

A common mistake made by novice game developers is assuming that "putting it on the web" is the same as distributing via the web. If the web page is one that does not already receive a lot of traffic, the product is invisible to the consumer. The difference can be huge. Kauffman's *All Terrain Brain* game, hosted on allterrainbrain.org, receives 1,210 unique visitors/month. In contrast, its *Hot Shot Business* game, hosted on Disney.com, receives 294,934 unique visitors/month – even though it is buried deep within the Disney site. Both are 2D flash games.

Making a non-top-ten website visible to the consumer requires off-site advertising and marketing. Martz [34] and Shingler [61] both discuss the need to submit new games to game review sites, game award contests (for educational games, SIAA's Codie awards), product review columns in magazines, etc., and to do so on a nearly constant basis. Remarks David Martz [34]: "Product reviews need to be high on electronic game sites – GameSpot, Metacritic, IGN, etc. And, you need to give them new screens shots every week, for at least 4-5 months before the game comes out." *Whyville* gathered its first 3,000 subscribers ten years ago via a series of kid-centric articles in the *LA Times* [28]. *Wolfquest* attracted its first adherents from a press release out of the Minnesota zoo, that ended up in Twin Cities newspapers, and then was subsequently picked up and posted by some readers onto the *Zoo Tycoon* and *My Little Pony* game forums [30]. *Wolfquest*'s user base was also inadvertently assisted by a cable TV station's mockumentary of *Wolfquest's* YouTube video [30].

While several game developers expressed the fond hope that social networking sites would become a stress-free and self-propagating mechanism for advertising, no developer interviewed had yet successfully taken a product to market intentionally using social networking sites as the primary marketing tool. The promise of all-digital distribution had yet to play out either; while digital game distributors like STEAM have significant (20 million [93]) registered users, they cannot yet substitute for the power of advertising through third party venues.

Consumer Acceptance

In discussions with serious game developers, few consumer acceptance issues arose with respect to the general public. No particular hardware or software features were cited as making or breaking a game for this audience. Inasmuch as the general public was interested in learning, it appeared to be interested in learning via game. Comparisons between serious game and entertainment game sales were inevitably depressing, but comparisons to other kinds of educational materials, like workbooks, much less so. In 2000, the book industry in total published 122,000 new titles and sold a total of 2.5 billion books, an average of 20,500 units sold per title [94]. This is well in line with the achievements of nascent serious game developers. And it may be that, for games, the right core audience – the adult continuous learner, the special needs learner, the advanced learner – has yet to be fully tapped by existing marketing and distribution approaches.

Conclusions: Achieving Scale in General Public/Higher Education Markets

Economic sustainability, distribution network, and customer acceptance are challenges for the general public audience, but are much less problematic than for the K-12 case. The numbers of units sold to the general public, for sales of the same product, is higher. Distribution is easier and can be achieved through established, turnkey 3rd party publisher/distributors or pure distributors. Consumer acceptance appears to be reasonable, in line with other learning products or non-entertainment offerings. Thus, all other factors being equal, serious games should reach their potential first, foremost, and best in the public market.

However, the number of serious games that have been actively/professionally marketed to the general public is few – and the number actively/professionally marketed to higher education appears to be approximately zero. Failure modes in this space seem to be 1) not having a commercial grade product in the first place (academic offerings that lack user testing, software robustness, etc and cannot be handed off to the public) 2) posting the product on a poorly trafficked website rather than using an a) publisher or b) a distributor combined with an aggressive marketing plan and 3) targeting the difficult and finicky child learner market (or worse, having no identified market at all). A fourth limitation, perhaps the root cause of all the above, is the lack of funding to conduct professional grade product hardening and marketing, especially for products developed on government grants.

Assuring High Pedagogical Quality for Serious Games in a Mass Market

At present, it is a struggle just for serious games to establish themselves in either the K-12 or general public/higher education markets. This is true for all the games, independent of game quality as measured by learning outcomes. However, the long term goal would be for serious games to achieve both quantity (succeed in mass markets) *and* quality (exhibit consistently high learning outcomes across products). The recommendations that follow assume we should lay the groundwork for both goals now. Thus, in addition to addressing the gaps that prevent serious games from taking a market hold, we offer suggestions on how to assure that, as their market grows, serious games consistently deliver top flight pedagogy.

Recommendations for Achieving Scale (and Quality)

1. *Explicit business/sustainability planning should be built into all proposals to the federal government where the implicit or stated outcome is improved learning by one or more target populations. We need to ensure these projects are able to reach their populations at a scale that will make a difference.*
    a. As a separate component of their grant proposal, PI's should submit a solid business plan that answers the question, "How will you reach scale?" Sustainability, distribution, customer acceptance are examples of separate sub-issues that could be addressed.
    b. Commercial game producers, venture capitalists, or others familiar with evaluating business plans (not academics) should evaluate this component of the proposal.
    c. This dual, parallel evaluation (research merit/ business plan) would be similar to the NIST-Advanced Technology Program process [95], with separately composed panels of experts reviewing the separate facets of each proposal.
    d. Structuring proposals in this way should result in more academic projects being correctly framed to be later taken up by commercial developers, venture capitalists, publishers and distributors, once the grant life is over.

2. *The Small Business Innovation Research (SBIR) is currently used by a number of would-be serious game developers to obtain funding for content creation. Federal agencies can use feedback on these proposals as a tool to educate the community on proper business/sustainability planning.*
    a. If the business/sustainability plan is deficient, reviewers' remarks should be given to PI's so they understand the issues they need to address in their next submission.
    b. Several game developers commented that National Institutes of Health SBIR process in particular gave zero business plan feedback. Submitters simply got "Accepted" with no comments. This represents a learning opportunity lost.

3. *The SBIR process should be accelerated, if possible, so as to provide a financial bridge for startup companies to make it to their first sale.*
    a. Six months' review time represents a death sentence for small companies. Faster review times would allow companies to work on the next product while establishing distribution channels for the first, and to attract more outside investment by appearing more robust to investors in the interim.

4. *The government should fund research that could possibly break open new markets for game-based learning, thereby giving it the opportunity to sustain itself in the commercial realm. In particular, it is both in the public good and the commercial interest to fund rigorous research on differential learning outcomes between high and low-performing students, or mainstream vs. special needs students, or advanced learners when taught by game.*

5. *Philanthropic foundations should consider establishing "bridge loan" programs that would provide funding to commercial entities to take on the software hardening, user testing, marketing and distribution functions for serious games software. This is a critical need in both the K-12 and general public/higher education markets. It is also one that cannot be fulfilled by government, due to incompatibilities with existing programs and direct conflict with federal grants and contracts regulations.*
    a. These serious games "business services" are currently impossible or nearly impossible to purchase/find, especially for K-12 but also for niche markets within the general public market.
    b. After 3 years, the loan would have to be repaid.
    c. This approach would takes business functions out of the hands of researchers not trained to perform these functions and put it in the hands of business experts with the right contacts and know-how.
    d. The requirement to repay the loan ensures only those products that have a reasonable chance at real commercial success will be taken on – prevents proposal "mills" from spawning.
    e. The requirement to repay the loan also makes the program self-supporting in perpetuity.

6. *To assure the software that reaches mass markets is of high pedagogical quality, the government should fund research that ties learning outcomes on individual games (both commercial and academic) to specific features or approaches of that game. The current lack of such cause-and-effect data on learning outcomes prevents game developers, and the field as a whole, from optimizing serious games for learning performance.*
    a. In addition, results of these studies should be aggregated into at least one reference location, similar to the "What Works" website established by the Department of Education.

7. *An unbiased and credible third party should establish a review board that can rate a specific serious games titles on both a) learning outcomes and b) user engagement (Does it teach? Is it fun/absorbing?).*
    a. This would be a composite ratings system (e.g., five stars for pedagogical quality and a separate five stars for user engagement). Both elements are necessary for a "successful" game.
    b. Game developers would be allowed to put the ratings on their product as a form of advertisement.

c. A website would log all results, positive or negative, of product evaluations. This website would serve as a resource for consumers interested in buying the games.

d. The measurement rubric to establish degrees of "pedagogcal quality" and "user engagement" should be developed by a very highly credible impartial source, e.g., The National Academies. Once the rubric is established, a different entity could then be responsible for conducting the measurements and issuing the ratings according to the rubric.

e. A visible consumer five star/five star ratings system would allow informed consumer choice to drive commercial markets towards the dual desired outcomes of higher learning outcomes and higher user engagement.

8. *State boards of education should adopt new criteria for the adoption of textbooks and other learning media in schools. These new criteria would speak to learning outcomes rather than topic coverage.*
    a. Substituting proof that the product improves individual learning achievement – rather simply covering a long checklist of topics – would stimulate both textbooks and learning games to be the best learning media they can be.
    b. Individual achievement should perhaps be measured in terms of improved skills rather than content knowledge. The ACT found that exactly three fundamental skills undergirded 85% of the 16,000 jobs it profiled: locating information,[6] reading for information, and applied mathematics [96]. Knowledge is all around us, on the internet and in books. Skills in finding, understanding and applying that knowledge are perhaps more germane to a 20th century education, and more useful for a population that will be shifting jobs continuously. If learning media are required to show they advance these fundamental skills prior to being adopted, we may be better preparing our future workforce.
    c. Eliminating the requirement for one learning medium to be all things for all people and all topics opens up formal education to a flowering of learning media, each targeted to a situation, topic or audience where it performs best.

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[6] Note the scientific method is one means of locating information (specifically, a means of finding information when that information does not already exist).

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