BREAKING EDUCATIONAL BARRIERS WITH CONTEXTUALISED PERVASIVE AND GAMEFUL LEARNING

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EXECUTIVE SUMMARY

Based upon the inventory established in task 3.2 the experts on business development within the consortium carried out this in-depth analysis of market trends including legislative and regulatory changes that will be carried out for the different national and European markets ensuring a successful exploitation of BEACONING solution across European and global markets. This analysis will include a SWOT table, analysis of the current trends in the field, identification of the market segmentation and market barriers, along with measures to overcome the barriers.

Leveraging games for learning is not to be just another passing fad in the history of educational technology. Young minds are curious and primed for change, but equally strong in resisting reinforced change! BEACONING environment is designed to foster learning curiosity and ultimately intended to encourage learners ("feel the need") to acquire knowledge and skills through the nurturing of intrinsic motivation as would be demanded in the gaming episodes, the same way it so happens in real-life.

1 INTRODUCTION

1.1 ROLE OF THIS DELIVERABLE IN THE PROJECT

The 7th work package of the project aims at founding an ecosystem for sustainable adoption project results in real contexts and in the broadest possible community. This community would naturally be a subset of the global game-based education community, yet with large-scale pilots it is expected to expand into mainstream education, reaching national level adoption in partner countries. The technology watch is essential to remain relevant to the global trends in game-based education, stay within, so that the impact is optimised. In particular, new business models need to be studied, since educational technologies are hard to sell. General public expects the educational assets be provided by the governments, but governments are not only ponderous in such purchases, but also conservative about the pedagogies used in formal education. Technology watch activity will help BEACONING to formulate strong value propositions, to side with de facto learning environments, and to seek sustainable models.

1.2 APPROACH

The perspective in observing fast changing developments of the game-based education market is focusing on:

i) techniques that blend seamlessly with formal education, and
ii) game concepts and mechanics that are fun and engaging enough to attract young generations most of whom are already hard-core gamers (while staying empathetic and sensitive to the spectrum of gaming literacy).

Special attention is devoted to inclusive education as provisioned by the project scope. The approach here is not only to provide better accessibility or some additional functions, but to also build into the system an adaptivity feature that would embrace special needs students within the same game flow as the others, who might also have their own needs and demands.

The quantitative information about the game-based education market and predictions are gleaned from three different market reports from global market analysis firms namely: Ambient Insight, Technavio and Wiseguys. These reports are referenced where appropriate.

1.3 STRUCTURE OF THIS DOCUMENT

The document consists of three main sections. The in-depth market analysis of the education gaming in EU is presented, followed by an overview of the state of the art of the technology in using games for engaging students in inclusive education. The final section is a discussion about how to evaluate project outcomes in ways that not only serve for validation but also for actionable feedback towards further development. At the end of each section, there is a reflection exercise to derive lessons and portable ideas for the BEACONING project.

The text includes numerous examples linked to the assertions and claims about the state of the market and the technology.

2 MARKET ANALYSIS

The idea of "learning as a game" is commingled with "game-based learning," or even "gamified learning," however there is a drastic difference. The former denotes learning experiences which are transformed into and primarily felt as a game, while the latter denotes using games to teach facts, concepts, procedures and other forms of "knowledge in pieces[1]". The difference becomes more accentuated when the idea of "education as a game" is compared to "game-based education", because these ideas involve instructional strategies as well.

In the 1980s and 1990s multimedia and digital presentation tools were embraced enthusiastically by parents, instructional designers, and software development companies since they made the course content more attractive. Yet it could never be proven that these tools yield deeper learning beyond their engaging quality. Students who were engaged by some other way could learn just as much[2]. The learner still had a "third person" relationship with the subject, with the content creator actually being the first and the teacher the second personas.

Since the mid-2000s, however, we have witnessed the development and spread of increasingly sophisticated computer games and digital content, as well as mobile computing devices that enabled access to the content anywhere, anytime. Content became an ambient resource forcing traditional pedagogical approaches to change. Social constructivism in the form of "Connected Learning"[3] is embraced, starting in adult training market, then penetrated to higher education and STEM high schools. Learning Management Systems (LMS) as used by online course platforms such as Coursera, Udacity, and EdX enabled self-paced, self-regulated learning and institutional LMS products gained social networking functions, first as an add-on, but then as a foundation.

The dominant form of engagement has shifted from content over the network to conversation over the content. Gradually students are becoming "first person learners", experiencing direct involvement with the subject area. Instructional design is increasingly based on active learning techniques and strategies. The scope of assessment has expanded to cover not only subject matter but also how well a learner integrates ideas and knowledge, advancing skills that are demanded in modern work places. Generation Z students (ages 10-25) are born into a world where "mass customisation" is no more an oxymoron, but a consumption paradigm which they took for granted. They already feel entitled to be "first person learners". Meanwhile teachers and educators from Generation X (ages 37-51) who are born into the world of computers, who seek balance in their work and trust the young, are willing to sacrifice control and let their students be autonomous.

[1] diSessa, A. (1988). Knowledge in pieces. In G. Forman & P. Pufall (Eds.), Constructivism in the computer age (pp. 49–70)
[2] OECD, PISA series (2015). Students, Computers and Learning: Making the Connection, retrieved from http://www.oecd.org/publications/students-computers-and-learning-9789264239555-en.htm

[3] Siemens, G. (2006). Knowing Knowledge, retrieved from http://www.elearnspace.org/KnowingKnowledge_LowRes.pdf

These advances have led to an abundance of digital games pressed into the service of education and used as a part of the active learning toolset. Encouraged by this foothold, educational games research is established as a new discipline of instructional design that formalizes the study of game design and development to be placed in formal education, to be integrated into curricula and into life in school[4].

The BEACONING project is set-up as an "Integrated Action" to carry the outcomes of this discipline to multiple countries in Europe at national level. The European market for educational games is not only smaller than the US and Asian markets, but also used to grow at a slower rate than the others. Interestingly, that trend seems to change after 2015. In this section, market segmentation and market barriers; along with measures to overcome the barriers will be discussed.

2.1 MARKET SIZE

USA based global market research company Ambient Insight releases a "Global Game-based Learning Market" report every year during the annual Serious Play Conference since 2011. This report includes revenues and growth rates of the market in seven regions in the world, including Europe, and a 5 year forecast. The firm follows learning technology markets in 122 countries and has been proven quite accurate with its forecasts so far.

According to the 2016 report, "Worldwide revenues for Game-based Learning products reached $2.6 billion in 2016. The global five-year compound annual growth rate (CAGR) is a robust 22.4%. Revenues will surge to $7.3 billion by 2021". It is also reported that "a total of $322.6 million venture capital has been invested in thirty-six Game-based Learning companies in just the first half of 2016, nearly double the amount for the entire year of 2015"[5].

Table 1. Game-based Learning Product revenues (source: Ambient Insight)

Year	Global Revenues in EUR Millions	East+West European Revenues in EUR Millions
2012	1,458	104
2013	1,638	122
2014	1,921	150
2015	2,143	159
2016	2,508 (forecasted figure in 2012 was 2,102)	183 (forecasted figure in 2012 was 143)
2021	6,877 (forecast)	241

[4] Whitton, N. (2014). Digital games and learning: Research and theory.
[5] Ambient Insight (2016). Global Game-based Learning Market. Partially retrieved from: http://seriousplayconf.com/downloads/the-2016-2021-global-game-based-learning-market/

The Indian market analytics firm Wiseguys forecast the global game-based learning market (in higher education alone) to grow at a CAGR of 13.95% during the period 2016-2020. On the same account, Ambient Insight forecasts that the growth rate for Game-based Learning products in the 2016-2021 period will be 22.4%. These forecasts are based on the fact that the 2016 growth rate is more than double the growth rate of 9.7% in the 2006-2011 period[6].

The growth rates for Game-based Learning products in North America, Western Europe, Asia, and the Middle East are 13.7%, 30.4%, 20.9%, and 34.5%, respectively. Africa has the highest growth rate for Game-based Learning at 55%, followed by Eastern Europe at 44.2% and Latin America at 35.9%.

This "accelerating" growth points to a shift in industry dynamics which will be discussed in the subsequent sections. A phenomenal increase is notable in the European growth rate which used to be lower than the US and Asian markets' growth rate since last 5 years.

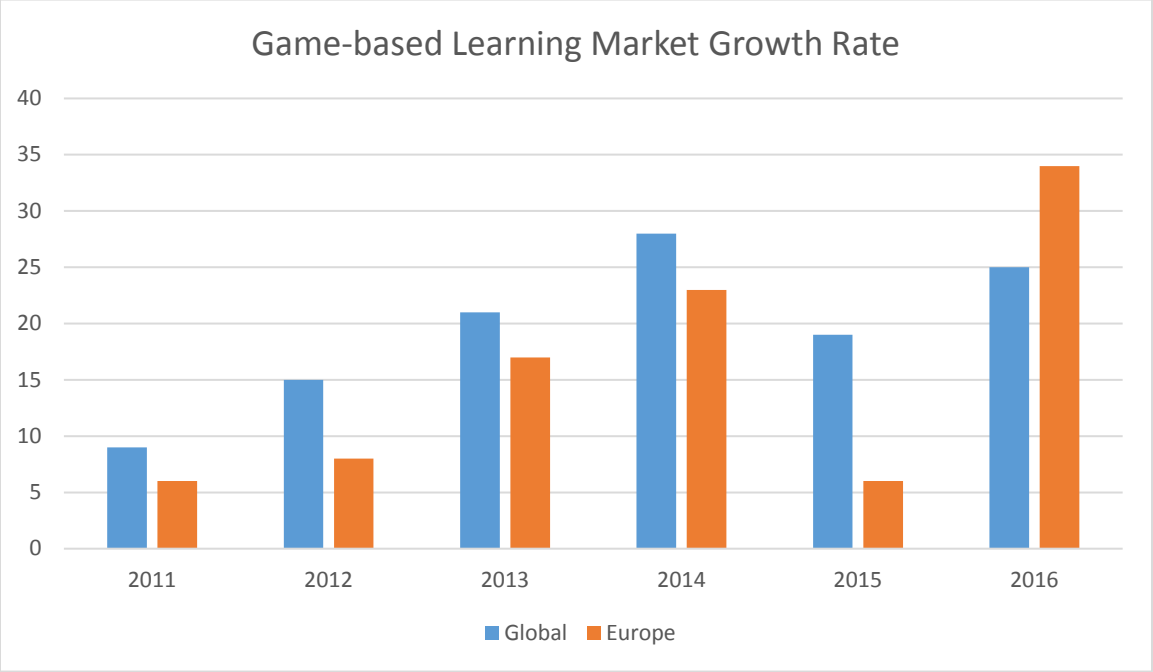


Figure 1. European market growing rate surpassing that of Asia and USA since 2014

(source: Ambient Insight, Wiseguys and Technavio[7])

Ambient Insight discloses that the products accounted in Table 1 and Figure 1 include only **edugames,** products that which utilize "game play", as an educational value, where there is an explicit pedagogical (or remediation such as with dyslexia) goal, some form of competition and a reward/penalty system that essentially functions as an assessment method. A user "wins" an edugame when they achieve the learning objectives of the gameplay. All educational games are designed for behaviour modification (learning), pedagogical intervention, or cognitive remediation. Remediation address not only cognitive

[6] Wiseguys (2016). Global Serious Game Sales Market Report.
[7] Technavio (2016). Global Education Gamification Market 2016-2020.

challenges (such as dyslexia), but also behaviour in areas of health and wellness, diversity, conflict management, team building, and leadership. The products also include (mini)games in virtual worlds such as Whyville, JumpStart, and Mingoville. In this case, although the environment is "simulated" the educational model is game-based. Other key vendors included were:

- McGraw-Hill Education
- PlayGen
- Toolwire
- Totem Learning
- BreakAway
- LearningWare
- Lumos Labs
- Corporate Gameware
- MAK Technologies
- RallyOn
- Sava Transmedia
- Visual Purple
- Triseum
- Designing Digitally
- Forio
- Innovative Dutch
- OakTree Simulations
- Rosetta Stone
- Triad Interactive Media

The reported product set by Ambient Insight includes neither simulation-based learning products such as aviation, or heavy equipment simulators for training, nor just gamified products where gaming rules, mechanics and conventions are applied to a nongaming situation[8]. Today, "adding" game elements to legacy education and training products is almost trivial. In BEACONING consortium legacy content developing partners such as SEBIT, SIVECO, SUCCUBUS and PLAYSOFT have all utilize gamification, at least in the form of badges and reward points. From the end-users point of view, partners such as ORT and COVUNI are also using the gamification process for engaging their students into game based learning activities.

Figure 2. SIVECO Silk Road and SEBIT Vitamin are examples of simulation-based and/or gamified educational content.

Today, gamification is so wide-spread that it is even available as services and platforms. For example, Badgeville sells gamification add-ons for corporate training. Course Hero has online courses that use Bunchball's game mechanics. Oxford University Press and Scholastic use SecretBuilder's game platform to "gamify books". GameEffective is providing a SAAS platform for embarking gamification into a non gaming process by defining a set of external rules and triggers. CaptainUp plugin for blogging (such as WordPress) has a distinct and user-friendly visual style that is "game like" to encourage engagement with blog contents. Mambo.io is an API dedicated to programmers that would like to enrich their

[8] Burke, B. (2014). Gamify: How Gamification Motivates People to Do Extraordinary Things.

educational contents with such gamification elements. Those frameworks and platforms help in setting up new educational gamified contents as well as transforming existing ones built by teachers by enriching them with gamified elements.

The recent surge in the market growth is neither due to gamification or the abundance of games that aim to transfer pieces of knowledge. It is due to a more global shift in pedagogy and formal schooling which positions students as “first person learners” and curricula that is based on competencies rather than knowledge spaces.

2.2 MARKET SEGMENTS

Market segmentation is discussed in 3 dimensions:

1. European countries;
2. Educational levels;
3. Product types.

Among European countries, the United Kingdom is the top edugame buying country, followed by Germany. France and Spain also have a large developer base, but both France and Spain combined, is not as big as UK or Germany in terms of turnover or the number of game companies/studios. Like almost all countries in the world, the edugame market in the UK is being driven by consumer demand for mobile edugames.

Table 2. International comparison main facts and figures about the games industry[9]

Country	Game Companies	Game Dev Studios	Jobs	Turnover	Year	Source
Netherlands	455	**352**	3030	190	**2015**	**Games Monitor 2015**
United Kingdom	**1.902**	-	10870	1490	**2013**	**Nesta (2013)**
Germany	-	**320**	10350	1820	**2013**	**BUI (2013)**
Romania	65	-	**5000**	-	**2015**	**Newzoo (2015)**
Spain	**330**	**260**	3380	**313**	**2013**	**Spanish Association for the Game and Entertainment Software Development and Publishing Industry (2013)**
Sweden	-	**213**	**3117**	**952**	**2015**	**Game Developer Index 2015, Swedish Games Industry's**
France	**600**	-	3000	-	**2015**	**Baromètre du jeu vidéo en France - 2015**
Finland	-	**260**	**2500**	**800**	**2014**	**Neogames Report Finland (2015)**
Czech Republic	125	-	850	-	-	-
Austria	120	-	750	-	-	-
Denmark	**190**	**171**	**735**	**148**	**2014**	**Interactive Denmark (ID)**
Belgium	29	-	200	41	-	-
Poland	**150**	-	-	-	**2015**	**The state of the polish video game sector (2015)**
US	-	-	**42000**	**3700**	**2012**	**ESA - USA 2014 report (data from 2012)**
Canada	-	**472**	**20400**	**2800**	**2015**	**Entertainment Software Association of Canada (ESAC)**

On the other hand, China is the top edugame buying country in the world. Consumers in China spent $621.7 million on mobile education apps and edugames in 2014; this is higher than the entire amount spent in North America in 2014. Early childhood learning apps dominate the top selling app rankings in China, followed by language learning apps. Eighteen of the twenty top-selling educational apps in Apple's store in China in June 2015 were early learning childhood apps. Essentially all early learning childhood apps contain game play. This trend was initiated in the 2006 to 2013 timeframe by the success of the extensive catalogue of new edugames running for the Nintendo DS. The demand for these Nintendo edugames recessed in 2009 and 2010, replaced by mobile apps of smart phones that diversified into brain trainers, cooking games, language learning games, and test prep games. Today every country has at least one edugame in its top twenty list of mobile apps.

[9] Koops, O. (2015). NEO Observatory Game Monitor. Retrieved from http://www.growinggames.nl/wp-content/uploads/2016/02/DEF_GAMESMONITOR_2015_DIGITAAL-1.pdf

Table 3. Game-based Learning market segment according to educatinal levels

(Source: Ambient Insight, Technavio and Wiseguys).

Buying Segment	2014 Game-based Learning Revenues in EUR Millions	Expected 5 yrs %Growth
Consumer	1,283	19
Preschool	21	34
Primary	136	28
Secondary	35	38
Tertiary	17	40
Government	86	25
Corporate	155	29

Notice in Table 3 that the consumer segment dominates the market. This is mainly due to the popularity of mobile games. The product types for these mobile edugames are usually brain trainers, language learning games or early childhood learning apps.

There is a market barrier in formal education for governments adopting edugames for schools, which will be discussed in the sections below. On the other hand, private schools in general use their budgets to introduce some games in school life. Among the educational levels primary schools are naturally the keenest to incorporate edugames in their curricula. The market is apparently in its infancy for secondary and tertiary schools. Students in these age groups play console games in their leisure time and need much higher play quality to turn to edugames for their studies.

However new assessment and evaluation edugames based on psychometrics are changing this situation, based on which these levels are expected to have a surge in growth during the next few years. Psychometrics is the science that focusses on statistical measurement of psychological states. Psychometric instruments measure knowledge, abilities, skills, attitudes, and personality traits. Several new companies that specialize in this type of edugame have come on the market in just the last 2-3 years including Pymetrics, Revelian, Knack, Scoutible, SHFuse, RoundPegg, Arctic Shores, and High Voltage Software. All of them are seeing rapid uptake, not only for older students but also in the corporate segment. Psychometrics based games are changing the recruiting process by using big data, neuroscience, and machine learning to identify optimal career paths for job seekers and ideal employees for organizations.

Assessment of cognitive abilities and personality traits using a series of fun and quick neuroscience games makes it easier to spot inherent qualities that can lead to success. In July 2016, Arctic Shores game development company made a distribution agreement with the talent assessment company Cut-e, which provides ability, personality, motivation, values, creativity and integrity assessments in 70 countries. Large multinational organisations also increased their orders from game studios to develop

tailor-made assessment games for their specific HR processes. In the US, the "Knack IT" company is enabling the gamification process into the HR recruitment processes for company to recruit new comers based on the identification of their knacks by playing minigame mobile apps that can reveal the players talents and skills and thus the adequation with the proposed job's opportunities.

Psychometric novelties are also driving test prep games, which are in high demand in so-called exam cultures, which are countries (like Turkey, China, India, South Korea, and Japan) that place a great emphasis on high stakes testing. Edugames to help students prepare for standardized English exams are also popular around the world. Most of the test prep edugames were in the form of knowledge-based quiz games.

Finally, brain trainer games which emerged in 2006 have moved on to a new generation with the discoveries in psychometrics, elevating brain trainers to become the top revenue generating product type globally in 2016. These discoveries mainly relate to skills and competencies and as a result brain trainer games have moved on to developing specific cognitive skills from the previous generation which used to target knowledge expansion or deepening. This development is occurring alongside increasing interest in STEM education, creating a new subgenre of brain trainers for STEM skills such as problem solving, meta-cognition and planning. Moreover, there is empirical evidence that some general skills such as visual attention, spatial intelligence and processing multiple streams of information simultaneously that can easily be improved by brain trainers predict higher achievement in STEM domains[10]. Collectively referred to as "Fluid intelligence", the ability to reason and to solve new problems independently of previously acquired knowledge is critical for a wide variety of cognitive tasks, and it is considered one of the most important factors in learning[11]. Inspired by the success of the brain trainer games for adults, there emerged games with puzzles or mini-games which targeted students studying STEM topics. The largely popular example set by Lumino City (see screenshots below) in 2015 was soon followed by The Song of Seven, Nelly Cootalot, Deponia, Goetia and Silence in 2016.

Figure 3. Lumino City educational puzzles screenshots.

The lead of brain trainers is expected to change over the next five years and immersive games will be the top revenue generating product type by 2021. Strategic games, such as StarCraft, Mass Effect and Final Fantasy also improve problem-solving skills, information gathering, decision making under stress,

[10] Makin, S. (2016) Brain training: Memory games. Nature. March 3. Vol 531.
[11] Jaeggi, S. M. (2008), Proc. Natl Acad. Sci. USA 105, 6829–6833.

strong ability to formulate and follow strategic plans, but the immersive games present a much greater opportunity. In formal education, immersive games, especially role-playing games with relevant challenges have the potential to present entry points to curricular subjects.

Since the project scope includes a meta-game, immersive edugames are of particular interest for the BEACONING project. Sub-categories of this type include:

- Experiential role-playing edugames (serving discovery learning);
- Location-based learning edugames (emerged in 2009);
- Mobile augmented reality edugames (emerged in 2010, faded in 2012 and 2013, and re-emerged in 2015);
- Virtual reality edugames (immersive types emerged in 2015);
- Epic games (immersive types emerged in 2013).

Some immersive games where a player experiences within and as a part of an alternative reality are as follows:

- Little Big Planet
- Lumino City
- Sims
- Civilization
- From Dust
- Kerbal Space Program
- Viliant Hearts
- Elegy for a Deadworld
- Riven
- Age of Empires
- Age of Mythology
- Ark
- Portal II
- Beseige
- Universe Sandbox
- Minecraft

Ark

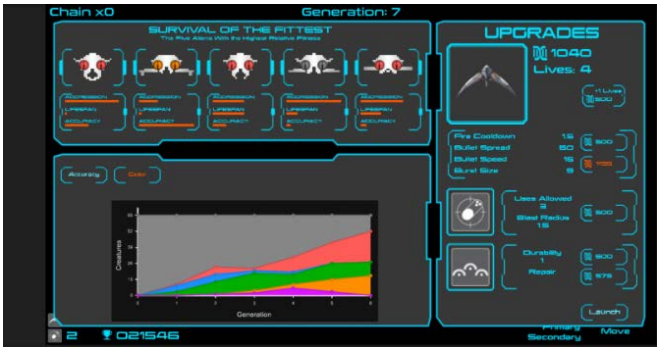
Kerbal Space Program

From Dust

Universe Sandbox

Figure 4. Screenshots from 4 serious games

These games are large, expensive productions, intended for quality game time, improving some cognitive skills but not serving any substance for curricular topics, except perhaps for history or geography. Some suit for simulation-based learning, such as Universe Sandbox for astrophysics or Ark for ecosystems, sacrificing from fluidity of gameplay. Darwin's Demons is a video game created at University of Idaho which runs on the idea that games can be better if the enemy can evolve to defeat harder. The difficulty of each level of the game is controlled by a genetic algorithm based on Darwinian natural selection. Similarly, the Radix Endeavor is a massively multiplayer online game (MMOG) for STEM learning in middle and high school. Radix Endeavor is developed by MIT Education Arcade.



Darwin's Demons

Radix Endeavor

Figure 5. Screenshots from some serious games developed by universities.

The same criticism from educational perspective also can be made for recent augmented reality location-based games that gained almost instant global popularity. Most prominent examples are from Niantic, Inc. which is a spin off from Google who produced Ingress and Pokemon Go. Niantic uses Google Maps infrastructure and GPS information. These games could help geography teaching and highly motivate young players for team activities.

The augmented elements overlaid on real world view of the smartphone camera are "triggered" by object recognition, print-based markers, barcodes, and geotags. Even though early attempts from 2010 on using this functionality in edugames have failed proliferation of new AR hardware and software being developed and marketed by large companies like Microsoft, Sony, Google, Intel, Apple, and Qualcomm enabled hugely popular new games in early 2015 onwards and today, all of the major technology players have some augmented reality location-based application plans, some as well including edugames. Microsoft plans to merge 3D capture functions of new Windows phones with Minecraft and Google is working with Mattel since February 2015 to launch a smartphone enabled View-Master product to take engaging field trips, explore famous places, landmarks, nature, planets, and more in 360 degree 'photospheres'. Specific edugames of this kind are being commissioned by science museums, zoos and theme parks, such as Disneynature Explore app, Chromville, or PTC's Vuforia. These apps in general target early childhood learning but for instance Vuforia or DAQRI's Smart Helmet have apps for industrial verticals.

The final subcategory of immersive games is called epic games. These are generally built around epic stories of moral conflicts, global challenges or foundational issues in humanities. The events of recent years that involve western and eastern countries alike, such as terror, income inequality crisis, immigrant crisis have everyone talking about civic literacy, global welfare or language of public agreement. Games which follow a story-line involving these issues, yet engage the players with challenges that demand STEM competencies and knowledge to tackle.

There are commercially titles of epic games such as Silence from the German game studio Daedalic Entertainment which also created famous Physics puzzle games such as Crazy Machines, but the production of epic games is as well initiated by global non-profit organisations such as UNESCO, World Bank, Institute for the Future and Games for Change. MIT's Education Arcade and Scheller Teacher Education Program are funded by the Bill & Melinda Gates Foundation to develop immersive virtual learning experiences supporting high school math and biology instruction. Gates Foundation sponsored other epic game titles or game-based education projects such as Atlantis Remixed or Refraction. Food Force (2) was an educational game published by the United Nations World Food Programme.

Atlantis Remixed Refraction

Figure 6. Screenshots from some educational games whose production was funded by global non-profit organisations.

Gaming ideas are created by thought leaders such as game designer Jane McGonigal[12] who is known for games such as World Without Oil, Evoke and SuperBetter, and author Max Barry who created NationStates. Other examples showcased by Games for Change are Life is Strange from a French studio called Don't Nod and Argubot from the US company GlassLab.

Life is Strange Silence Evoke

Figure 7. Screenshots from some serious games with epic quests.

In June 2016 GlassLab had a partnership with Take-Two and Firaxis Games to bring a modified version of Civilization V called CivilizationEDU to high schools. Previously, GlassLab had another partnership with Electronic Arts and Maxis to publish SimCityEDU. In creating the educational versions of these two

[12] McGonigal, J. (2015) SuperBetter: A Revolutionary Approach to Getting Stronger, Happier, Braver and More Resilient.

popular games, SimCity and Civilization, **GlassLab incorporated a learning analytics engine** to capture students' progress and assess a set of Student Model Variables and make claims on the proficiency of the student on certain skills such as problem-solving, communication, and collaboration. Some of the Student Model Variables can be explicit that is directly observable, but some others could be latent variables, meaning they cannot be assessed with test items. Interactive entertainment during game play presents an opportunity to use techniques developed for adaptivity in Intelligent Tutoring Systems to make claims about proficiency[13]. GlassLab uses Bayesian Inference Networks (BayesNets) with normalization so that influences that the player experiences are also accounted for. Incorporating features of situations in the game into the probabilistic models of the BayesNets enables more accurate claims on proficiency.

Every action the player takes in-game is tracked and used to assess how well that student is applying certain critical thinking and problem-solving skills. GlassLab reports that:

"*CivilizationEDU will provide students with the opportunity to think critically and create historical events, consider and evaluate the geographical ramifications of their economic and technological decisions, and to engage in systems thinking and experiment with the causal/correlative relationships between military, technology, political and socioeconomic development".*

The set of formative assessment tools embedded in the game code allows GlassLab to analyse student proficiencies in using the elements of the game for problem-solving and make claims in the form of assessment arguments. Such embedded assessment techniques are called "stealth assessment[14]" and refer to evidence-based assessments that are woven directly and invisibly into the fabric of the gaming environment. During game play, students naturally produce rich sequences of actions while performing complex tasks. Evidence needed to assess the skills is thus provided by the players' interactions with the game itself. GlassLab published a free whitepaper[15] called "Psychometric Considerations in Game-Based Assessment" in early 2014. Co-authors of the report include researchers from the Institute of Play, Educational Testing Service (ETS), Electronic Arts, and Pearson's Center for Digital Data, Analytics and Adaptive Learning.

GlassLab's research and development efforts are also supported by non-profit organisations such as John D. and Catherine T. MacArthur Foundation and the Bill & Melinda Gates Foundation.

Another commercial example is Filament Learning (a division of Filament Games) which sells a range of roleplaying edugames for a variety of academic subjects including biology, astronomy, math, archeology, and civics.

Finally, Odeum Learning is a new company that launched in 2016 with a successful Kickstarter campaign. They target the academic segments with a prefabricated 3D role-playing environment and an authoring platform allowing teachers to develop their own role-playing edugames. "Odeum" means "a small

[13] VanLehn, K. (2008). Intelligent tutoring systems for continuous, embedded assessment. In C. Dwyer (Ed.) The future of assessment: Shaping teaching and learning. pp. 113-138.
[14] Shute, V. J., & Ventura, M. (2013). Measuring and supporting learning in games: Stealth assessment. Cambridge, MA: The MIT Press.
[15] Mislevy, J. R. et al (2014). Psychometric Considerations in Game Based Assessment.

roofed theatre of ancient Greece and Rome". The company offers an immersive environment to experience educational role-playing adventures for engaged learning. These adventures are customised by teachers or learning designers to inspire students and help teachers to track results.

Figure 8. Screenshot from Odeum serious game about history.

Teachers who use Odeum do not have to develop any code to differentiate learning for their students. They can not only customize any game in Odeum, but also create their own, use an existing game as a template or start from scratch. The intuitive UI of Odeum guides teachers through a series of drop-down menu type selections where they choose a Stage (3D Environment) that game takes place in places such as; Paris, Historic Boston, or a battlefield. They then chose Actors (3D Characters) and assign dialogues and behaviors. **Finally, they setup Quests which can be learning objectives.** There is no programming required.

Odeum has set up a P2P marketplace in the autumn of 2016 for teachers to share or sell their creation. The revenue will be shared with Odeum.

Odeum is created using Unity cross platform 3D game engine which can render rich 3D environments. Unity is a free game engine, developed and maintained by a Danish company called Unity Technologies. Unity claims that, as of December 2016, more than 770 million people are playing games that run on Unity engine, more than 2 million developers use Unity engine to build games and those Unity based games for smart phones have been downloaded more than 5 billion times on 2.4 billion unique mobile devices[16]. The growth of Unity is accelerated by support from large software companies such as IBM, Intel and Nvidia as well device vendors such as Apple and Xiomi to enable Unity run on their product.

[16] Fast Facts about Unity. Retrieved from: https://unity3d.com/cn/public-relations

Additionally, these companies also help building up communities. Intel Game Dev is an initiative that help game developers partner with key game industry experts, access to tools, information, and monetization opportunities. IBM is also opening up new avenues by integrating its AI product Watson SDK to Unity to enable cognitive functionalities in games!

Note that Unity also launched their Unity Educator Toolkit in a bundle of free training content and discounted platform licenses for postsecondary institutions in June 2016.

Figure 9. Odeum authoring pipeline.

2.3 MARKET TRENDS and DRIVERS

As of 2016, Game-based Learning has the highest five-year growth rate among the main categories of learning technology products such as mobile learning or simulation based learning. This is an unusual trend for a learning technology that has been on the market for decades and indicates a new phase of its market. The new market phase is shaped by:

1. Rising use of AR and VR in game-based learning;
2. Growth in adoption of tablets;
3. Stronger focus on experiential and inquiry-based learning;
4. Pressure on higher education institutions to produce outcomes.

Game based learning is empirically proven to support skills acquisition and reinforcement by presenting engaging situations and challenges for learning to occur. The increasing demand for competency based education (esp. in STEM areas) is the main driver for the market shaping up this way. For instance, augmented reality-based decision support is a good example of a worker learning to do tasks as he or she actually does the work on site in the real world. Other drivers include:

1. Rising enhancement of student and faculty experience;
2. Increase in venture capital investments;
3. Improvement in game development engines;
4. Growing use of motion-sensing technology in game-based learning;
5. Strong global popularity of brain trainer and language learning apps (particularly English and Chinese).

2.4 MARKET INHIBITORS and BARRIERS

The use of learning games, especially those that also present some sort of simulation has long been a staple in police and military organizations and civilian agencies. Yet, there has been a history of resistance to edugames in the corporate segment and to a lesser extent in the academic segments mainly due to their playfulness. Until recently, game-based learning was perceived to be incompatible with the corporate culture and very time consuming and expensive to develop. This has changed dramatically in last few years. Specifically, game-based recruiting and job application assessments are rapidly gaining traction, creating the breakthrough moment for the uptake of Game-based Learning by corporations and businesses. On the flip side, the learners, especially young learners, who are used to the visual quality and gameplay dynamics of console games regarded, so called, serious games lacking fun elements. Amplify was one of the largest educational technology companies which went bankrupt in 2015. Zach Barth, the founder of Zachtronics, which developed "MetaboSIM" (a game about metabolism) "HabiTactics" (ecosystems) and "FAKTR" (factorization) for Amplify, reportedly said (after the bankruptcy) that “the world of schools is big and insane, and totally out of reach, so we don’t get a lot of feedback about how the games are being received. Once we found out what the market is like for educational games, that totally destroyed any hope. I’m so glad to not have to label our game as

educational. Because you know what? We're going to sell so many more copies by having a game that's not called educational, but is secretly educational".

There are other barriers as well for games to make in-ways to the formal education. One main barrier is the **legislative and regulatory changes in EU about data privacy.** Data privacy should not be confused with data security. End-to-end data security can be established by encryption, but data privacy demands control on the role based accessibility of data in store or in transmission, where the role based authorisation rules are set by laws or governments or even the real person who the data belongs to.

In January 2012, the European Commission proposed a comprehensive reform of data protection rules in the EU [17]. On 4 May 2016, the official texts of the Regulation and the Directive have been published in the EU Official Journal in all the official languages. While the Regulation will enter into force on 24 May 2016, it shall apply from 25 May 2018. The Directive enters into force on 5 May 2016 and EU Member States have to transpose it into their national law by 6 May 2018.

The objective of this new set of rules is to give citizens back control over of their personal data, and to simplify the regulatory environment for business. A hallmark of the European Commission's 2012 proposal is the "right to be forgotten" provision (Article 17), which, in case of children, could be exercised by their guardians. The previous Directive did not address the privacy of children, and there are no national laws in Europe similar to the Children's Online Privacy Protection Act (COPPA) in the United States. By contrast, the new Regulation has provisions on protecting the privacy of children (Article 8). Note that COPPA triggered establishments such as "Common Sense Education" which ranks and evaluations apps, games and activities for kids, proving the effect of legislation on the business ecosystem, which may be the natural outcome in Europe as well.

The age threshold for parental consent was much debated and kept changing right to the end of the legislative process. It was finally set at 16 by default, but Member States are allowed to lower it to 13, the age used in the US under COPPA. The national variation in threshold ages could be a challenge for the operators of websites and mobile apps. Specifically, the consent of a parent or guardian is required to process personal data on a child under the threshold age when offering any "information services," although this provision expressly does not change the age of legal consent under national law to enter into a contract. The Regulation contemplates that the European Commission may establish practicable methods, perhaps similar to those in USA, to obtain verifiable parental consent, but this transition phase adversely affects governments to provision information services to public education. The Regulation expresses the new principles that data controllers are responsible for designing and implementing mechanisms to protect personal data in conformance with the Regulation and ensuring that, by default, personal data are collected and used only as necessary for specific purposes, retained no longer than necessary, and not made available to an indefinite number of persons.

The legislation in Turkey has also been updated in November 2016, introducing similar, if not more stringent rules on privacy. Turkish legislation has not entered into force yet, but when it does it will be forbidden for information service providers to know which real person the data belongs to. For

[17] Reform of EU data protection rules. Retrieved from http://ec.europa.eu/justice/data-protection/reform/index_en.htm

instance, those vendors who provide remote assessment services via online exams and test prep software will no longer be allowed to determine real identities of the students who are successful or not, while the schools or the students themselves will be able to know. This level of control on privacy of data requires new technical solutions such as "Secure Stateless Tokenization" or "blockchain", that would allow varying, role-based authorisations on the same data.

The counter force to these barriers is especially mobile technologies and game engines that are advancing to let high quality productions be possible with lower budgets. Developments in psychometrics to produce reliable assessment claims, based on activities that take place in a game, proves to offer a high enough value-add to influence the buying behaviour of consumers and corporate users. More teachers are using games in the classroom, and more adults who grew up playing games are becoming parents (or teachers). Combined with increasing global sales of mobile games and a growing body of supporting research, game-based learning is already getting a part of national curriculum.

Arlanda highschool in Sweden has included computer games in its curriculum for the first time. The so called "e-sport" class has been reportedly popular and successful. While other schools in Sweden and Norway are considering introducing the subject, there are hardly any other examples from Europe. On the other side, in USA, in 2015 48% of teachers said they use games in their lessons, up from 30% in 2012, and only 23% in 2010[18].

On the other hand, UNDP (United Nations Development Programme) has 17 global goals such as "end poverty" "end hunger" agreed by 193 world leaders to be achieved by 2030 and one of them is "quality education". In line with this goal, UNDP initiates edugame projects, particularly for early childhood in Latin American and African countries. These "Education as a Game" aka "Gaming the Education" projects are expected catch up and others such as WEG and UNICEF projects.

Another non-profit driven epic game attempt is the UThink project which was funded by the Esmée Fairbairn foundation in UK and aimed to develop a serious game to instruct teenagers in ways to regulate their emotional intelligence. Low emotional intelligence is correlated with teenagers getting into conflict situations with authority figures. The project team took a set of already assembled worksheets, that had previously been used with teenagers in one-on-one sessions with caseworkers, and sought to embed the learning from those worksheets into a game, with the very teenagers participating the design process[19].

This trend for non-profit organisations and foundations sponsoring or commissioning epic games are expected to continue and the resulting games are somewhat more likely to get incorporated in formal education.

[18] Project Tomorrow, Research Report (2015). From Print to Pixel: The role of videos, games, animations and simulations within K-12 education. Retrieved from: http://www.tomorrow.org/speakup/SU15AnnualReport.html

[19] Mazzone, E. (2012) Designing with Children: Reflections on Effective Involvement of Children in the Interaction Design Process, Ph.D. Thesis, University of Central Lancashire, UK.

On the publishers' side, "Practice" is a series of 3D multiplayer learning games from McGraw-Hill Education. Designed with subject matter experts, these products integrate with core curriculum to deliver immersive learning experiences and rich assessment capabilities. Practice titles also work with McGraw-Hill Connect®, a digital teaching and learning environment. Therefore, instructional material and lesson plans can be incorporated into the Practice games.

2.5 BUSINESS MODELS

Consumer spending on Game-based Learning products across the planet accounted for 72% of all global spending in 2016. Adoption is gaining traction in all the other segments. By 2021, consumers will still account for 62% of all Game-based Learning expenditures.

The highest growth rates are in the preschool, tertiary, and corporate segments at 34%, 38%, and 40%, respectively. Except for the primary education sub-segment, revenues are still relatively low in the other academic segments.

What are the business models that govern these revenues?

The first business model is to go with telecom operators. Incumbent telecom operators are major distributors of edugames in Asia, Latin America and Africa. They make content deals with edugame suppliers and bundle the content to their products. They sell web-based learning platforms to schools and mobile learning apps Value-Added Services (VAS) subscriptions on the same telecom bill. BEACONING partner SEBIT is owned by Turkish Telekom and pursue similar strategies.

Similarly, South Korean operator SK Telecom sells the Albert robot bundled with the Smart Robot Coding School training program developed by SK Telecom teach children how to develop software. The product has been sold to schools in South Korea, Spain, France, Brazil, Colombia, Taiwan, and Malaysia. In May 2016, SK Telecom signed an MOU with the Central State Government of Paraguay to supply 10,000 units of the smart learning robot to schools in the country.

Note that, many new educational robots designed to teach kids programming and related skills have entered the market over the past year including the Vortex, the Kamibot, the Fisher-Price Codea-Pillar, Codeybot, Aisoy, and Ozobot.

The second business model is monetization in app stores. Unfortunately, in some countries (like China) Google Play is not authorized to receive payments. Nevertheless, there are some edugames among the top 20 best-selling educational apps in every app store in every country.

The third business model is pursued by or with publishers. Global publishers sign license agreements with local publishers to localize their games for specific countries. An example could be Toca Boca which is a Swedish game development studio focused on child-friendly applications for tablets and smartphones. The company has 29 employees but is able to serve 160 countries via local publishers.

A forth business model is to promote the visibility of other products or public service announcements as it would be sponsored by the government.

Even though there are rare cases big production can pursue direct to market strategies as well. GlassLab intends to sell annual online subscriptions of CivilizationEDU to schools for between $2 and $5 per student. In June 2016, GlassLab reported in the press that their serious games were being used in more than 10,000 schools across the US and Canada.

Finally, starting Autumn 2016, Odeum will be launching a marketplace of P2P-based model of sharing revenue with Teachers who would provide content on their authoring platform.

2.6 BEACONING REFLECTION

BEACONING system involves a meta-game with a vault of narratives (which are essentially role-playing games) that could be adopted by learning designers in play-lesson plans that stem from the narrative. The narrative can be used as an engaging entry point to STEM subject matter or projects further in the classroom or laboratory. Teachers may initiate discussions in the classroom or in the lab about challenges in the game and move thereon to subject matter. This method should invoke a "need to learn" in the students and gather their attention on the topic.

These discussion/enquiry activities that stem from the meta-game can also be starting challenges in the play-lesson plans. Detailed definitions of these concepts and their role in the system can be found in Deliverable 3.3 Learning Environment System Specification (M8).

The most relevant examples in this section to the BEACONING environment are McGraw-Hill Education: Practice and Udeum platform. As relevant to BEACONING functions of location-based adaptivity and competency-based learning analytics dashboard, GlassLab Game-Based Assessment functions and location-based games.

Gamification is the process of taking something that already exists - a website, an enterprise application, an online community - and integrating game mechanics into it in order to motivate participation, engagement, and loyalty. Gamification takes the data-driven techniques that game designers use to engage players, and applies them to non-game experiences to motivate actions that add value to your business.

According to this definition BEACONING is a divergence from the gamification approach to invigorate learning activities and rather an attempt to realize "education as a game" paradigm. Instances of recent brain training games that would improve STEM skills can be among the mini-games that the BEACONING platform can harbour, but the learning environment as provisioned by BEACONING is planned to be an immersive experience, reminiscent of epic-games. The meta-game can be regarded as an "epic challenge", linking the project to the global momentum for quality education. Authoring Tool Booklet claims this meta-game provides both the gamely and the narrative framing for all the Missions and Quests of the Play-Lesson Paths.

3 GAMING for INCLUSIVE EDUCATION

Inclusive education means that all students attend and are welcomed by their neighbourhood schools in age-appropriate, regular classes and are supported to learn, contribute and participate in all aspects of the life of the school. That principle would include but is not limited to disadvantaged and to a certain extent disabled students as well[20]. However, a well-designed inclusive education can be expected to expand personalisation to cover all students who might be falling behind or even have specific needs due to their advanced talents.

On the whole, students with disabilities have lower levels of academic achievement which result in poor employment opportunities. Disproportionality this is widespread in special education. Counteracting this situation, inclusive education implements equalizer strategies and involve special needs students in the same group activities, providing access for such students to the general curriculum. If this can be carried out across educational levels these individuals also become economically productive, not only able to support themselves, but contribute to the national income as well. Indeed, most countries are becoming increasingly diverse. Diversity often leads to prejudice and conflict, but if the social cohesion can be established, diverse groups prove to be more resourceful and better apt at solving big problems. Developing inclusive societies and global community is both a means and an end.

Implementing inclusive education is not easy: School building and classrooms have to have suitable accessibility, even at times of disaster and conflict; educational policy has to be revised, not only on promoting inclusion but also on transition from school to post-school situations; wraparound services need to be developed. But these are relatively easier issues. The harder part is to develop and deliver appropriate teacher education programmes to ensure teachers are making the right decisions about mixed ability grouping of students, employing evidence-based pedagogy, providing individualized support, and implementing universal designs for learning.

Educational games can be powerful tools to implement inclusive education. Games are social affairs, that improve the social cohesion. Additionally, games get the learners in the flow state of optimal performance and that, regardless of their (if the game design is right) predispositions. There are three conditions to induce a flow state:

1. Perceived Autonomy: The players should feel that they are in control, the more they attend to the task the more they could command;
2. Perceived Acceptance: The players should feel that they are rewarded for their achievements;
3. Perceived Challenge: The players should feel that they are neither exhausted nor under-challenged in which case they are bored.

3.1 CONTROLLING THE ATTENTION SPOTLIGHT

DIESEL-X is a computer game that was developed to detect a high risk for developing dyslexia in preschoolers. The game includes three mini-games that test the player on three skills that are considered to yield outcome measures that predict the onset of dyslexia: the detection threshold of

[20] Mitchell, D. (2016) Diversities in Education: Effective ways to reach all learners. Routledge.

frequency modulated tones, a test on phonological awareness in which the player has to identify words that have the same phonetic ending, and a test on letter knowledge. In order to keep the motivation of the player high during testing, these tests are embedded into a computer game.

Akili Interactive Labs brain trainer games assess the cognitive states of users. Their cognitive gaming engine enables remote data-capture, with features designed for extreme patient engagement. The software automatically personalizes to the patient's ability level with no clinician input required.

Halo Neuroscience "develops neurotechnology to unlock human potential in both the healthy and impaired". Their first product, Halo Sport, stimulates the motor cortex to accelerate gains in skill and strength acquisition when paired with athletic training.

Human attention is like a spotlight. The brain can process and absorb a limited amount of information "at a time", ignoring everything else. As a result, all information sources (sights, sounds, smells, thoughts, physical sensations) competes for brain's attention. Without conscious intervention (which is tiring), the attention spotlight is more likely to shift to one of these and away from the study topic if the person is in a classroom. Games are affective environments to help steer off the attention spotlight and in time let the player develop autonomy over his/her actions. Therefore, games have been shown, also with fMRI studies[21] to help PTSD, fend off unwanted thoughts, feelings or physical sensations and even curb cravings. Multiple studies have shown that playing Tetris for three minutes while feeling an intense craving cuts the intensity of the craving by 25%.

3.2 REWARDING

The brain is a "malleable" organ that takes "shape" depending on a neurotransmitter called "dopamine[22]". The points, badges and other currencies in a game environment conditions the dopamine network in the brain and let the brain operate in the way the game designer thought best to play the game. Of this mechanism, one of the strongest influences is "unexpected rewards".

In a seminal 2009 study, reported Science[23], a team of neurosurgeons at the University of Pennsylvania Medical School, used Deep Brain Stimulation (DBS) microelectrodes to study some of the neurons that participate in the brain's "reward and motivation" system. Some of the more important neurons that respond to unexpected rewards in animals are found in the dopamine-producing, midbrain structures. Researchers placed electrodes at these structures to eavesdrop on neurons in ten people with Parkinson's who were about to undergo DBS surgery.

While their neurons' firing patterns were being recorded, the patients played a standard reward-learning game, featuring two decks of cards-one blue, one red-on a computer screen. They were asked to choose cards from either deck to determine which deck had the higher proportion of "reward" cards. When a reward card was chosen, the screen displayed an image of gold coins with a counter showing

[21] Barlow, D. H. (2014). The Oxford Handbook of Clinical Psychology. pp. 638-641.
[22] Previc H. F. (2009). The Dopaminergic Mind in Human Evolution and History.
[23] Zaghloul K. A. et al. (2009). Human Substantia Nigra Neurons Encode Unexpected Financial Outcomes Science 323: 1496-99.

accumulated gains, and a speaker played the ringing sound of a cash register. Other cards brought losses. Using this feedback, they learned quickly to choose the deck with the higher reward probability.

The researchers took the choices each patient had made over time and fitted these to a standard model of reward expectation for a sequence of events. They used this model to classify each gain or loss as either expected or unexpected. They found that for unexpected gains, as compared with unexpected losses, one or more clusters of dopamine neurons near the implanted electrode increased its firing rate significantly during a crucial response interval after the gain or loss feedback was presented. For expected gains and losses, there was no significant difference in firing rates.

3.3 PROCEDURAL CONTENT GENERATION

At the flow state a player experiences challenges that are neither overwhelming nor boring. Game mechanics are usually designed to be adaptive or adaptable to keep the player within that band of engagement. Adaptive systems generally have three categories that differ by structure:

1. Rule-based systems: Equipped with a rules engine, these systems pick the next content part or the procedural branch based on a set of rules. The rules must not have conflicts or loop on each other. Therefore, special rule definition languages are used that can be compiled to verify these potential conflicts, gaps, loops or inconsistencies;
2. Human-in-the-loop systems: These are essentially decision support systems that present a human instructor or guide with a limited set of options and information about each option so that the responsible human would make the choice of procedure;
3. Evolutionary systems: Adaptive by nature, these systems employ machine learning techniques to model users and match the most likely content or procedure that would yield better learning specific to that user. Statistical analysis on data that is accumulated over time is used to reinforce or supervise modelling algorithms.

The rule-based systems rely on expert judgements to determine the exact rule set. Yet the other two types of adaptive systems need data, essentially from a variety of sources, to be able to model the user and operate. Computational approaches to activity learning from sensor data aims to discover activity patterns, to recognize occurrences of predefined or discovered activities in real time and to predict the occurrences[24]. Analytics on distributed data over time makes it possible to discover causal relations and so can guide a game engine to intervene with play to keep the users in the flow state.

3.4 BEACONING REFLECTION

Allowing for diversity by supporting inclusive education naturally brings value education and humanities focus (concerns such as ethics, justice and democracy) to an otherwise neutral studies on STEM topics. Below is a SWOT analysis of further reflections on the relative position of BEACONING against the technologies covered in the sections above.

[24] Cook, D. and Krishnan, N. (2015) Activity Learning: Discovering, Recognizing and Predicting Human Behavior from Sensor Data.

BEACONING platform has the following STRENGTHS given the current state of game-based learning for inclusive education:

1. If designed good enough the game-based activities would present a level of difficulty, bordering the outer limits of each student's abilities which is not possible with typical school activities;
2. Adaptivity not only at interface level but also in game procedures, controlled by not only players' learning abilities but also at competency level;
3. Adaptivity also enables BEACONING to be used for independent practice and self-assessment;
4. Gaming enhance motivation, engagement and eagerness to learn;
5. Integrating game-based learning into the curriculum supports computer literacy skills, systems thinking, problem solving skills and real world applications all relate strongly with STEM education;
6. An absorbing, immersive BEACONING meta-game narrative would entice the player to learn and invoke a need to study so that the challenges presented can be met;
7. Gaming induces a positive mood and attitude, making assessments based on games more reliable;
8. Social bonding within the game promote social learning and emotional anchors for newly learned concepts;
9. Using beacon sensors involves the physical environment in game flow, reducing costs, increasing relevance and improving adaptivity;
10. Teachers who would create or customize content would be deeper involved in students' learning process and potentially scaffold better, especially at enquiry-based activities which yield better conceptual understanding in STEM education;
11. Students would have a more active role and a first-person relationship with the learning process;
12. Most games make students spend a lot of time sitting at a computer or console while BEACONING games would let them be physically active;
13. Each challenge in the platform design is well met by capable and track proven partners in the consortium;
14. BEACONING games can be customized to account for individuals with disabilities and include them with others in the same game-based learning activity;
15. BEACONING challenges that are team-based will foster the engagement and motivation of individuals students, reinforcing collective learning and intelligence.

BEACONING platform has the following WEAKNESSES given the current state of game-based learning for inclusive education:

1. The assessment methodology, being performance based, may not be rigorous enough for formal assessment and guidance;
2. Not all students may be equipped with mobile devices for location-based gaming or it may be too expensive for some schools. Nevertheless, workaround solutions have been defined for simulating location-based events (QR Code scan) or manual identification of student location;
3. Any potential business model would depend either on the popularity of the games presented or the capabilities of the authoring pipeline;
4. Non-naturalistic interactions with the environment in location-based gaming;

5. Immature educational or gaming material as created by novice teachers in game-based education;
6. Authoring software may feel too difficult to be used by some teachers. The authoring tool is foreseen to be accessible both for Learning designers (that can define all the different parts of the learning path) and also by teachers that have the option to confirm predefined options defined by one learning designer;
7. Poor platform compatibility with legacy LMS and SIS systems;
8. Some students may develop an addiction or extreme indulgence for this model of education;
9. School policies may not let mobile devices to be used;
10. Teachers may not find any time for authoring or even customization, especially considering the time it will take the students to exploit the games. In that sense, ready to use scenarios shall be developed and proposed to teachers;
11. Educational system in some countries may be too rigid;
12. It is hard to strike the right balance between learning and enjoying. Students may not be able to differentiate game as exercise from game as entertainment or students may get bored with the games, missing the learning opportunities further on;
13. It is hard to strike the right balance between supporting STEM competencies and curricular subject areas;
14. Human-in-the-loop analytics approach may not appeal to all users;
15. Time spent in gaming may risk the accomplishment of the lesson's objectives.

Game-based learning for inclusive education market, in its current state, presents the following OPPORTUNITIES for BEACONING project:

1. If games can be localized with minimal effort, a global audience can be reached;
2. There is a growing trend for multinational non-profit agencies to support educational games;
3. Performance analysis and feedback in real-time;
4. Enabling just-in-time learning;
5. Emerging advances in technology such as mixed-reality or phones with more sensors;
6. More teachers and students themselves getting more literate in coding and modelling growing the pool of potential authors in the pipeline;
7. Easier grounding of subject matter with real life experiences;
8. Distance education platforms would have a value-add to include BEACONING games;
9. For teachers who would be a part of the content creation pipeline, it will be an exercise of creativity, knowledge construction and immediate application of theoretical knowledge. For teachers, it will help in their digital transformation by creating and proposing game based learning activities to their students.

Game-based learning for inclusive education market, in its current state, presents the following THREATS for BEACONING project:

1. The choice of technology for controlling adaptivity (if rule-based then it may not be complete or consistent, if probabilistic then there may not be enough training data);
2. Ethical challenges;

3. Possible side effects of unrealistic game narratives, confusing up immature ideas of young students about what is real and what is imaginary;
4. Poor integration with the educational practice;
5. The potential business models not providing enough incentives to each stakeholder in the ecosystem of value creation with BEACONING;
6. Technological advances overshadowing educational targets;
7. Some teachers or students not being apt at using technology, some parents having prejudice about the value of games;
8. Not all games raise the same level of interest. Typically, game publishers consider themselves lucky if only some of their game titles are profitable and if just one is a hit. Only 0.1% of mobile games are profitable. Rovio had reportedly failed 51 times before their "overnight success" in Angry Birds;
9. Some players having a me-first attitude in the game, risking achievements of other participants;
10. Inability to employ advanced enough technology required by very demanding privacy requirements of new legislations and policies;
11. In some groups there exists students whose regards affect the whole group, and the influence of negative comments by such students in activities which lack teacher authority is usually very high;
12. What is engaging as a gaming narrative or experience for one person may be inappropriate or dull for another. Some students who care alot about the subject content and learning activities, care less about the gaming elements (or vice versa);
13. Technical integration may break up during heavy use of real-time gaming at large scale during pilots;
14. The business models may be too much sales oriented and ignore the other costs games bring such as maintenance, change requests, variation requests, distribution, assessment, internal promotion and IT support. Mattel, Lucas Entertainment and Amplify all failed with their edutainment or serious games investments.

4 EVALUATION FRAMEWORKS

Capital or private equity investment in a new technology or service is risky. Venture capitalists aim at minimizing the risk of market penetration. On the other hand, it is generally the case that a technology with a lower risk of adoption would provide less profit to the investors as the technology creator would value accordingly. Therefore, a number of evaluation frameworks have been developed for due diligence.

4.1 TECHNOLOGY ACCEPTANCE MODEL

The Technology Acceptance Model (TAM) is an information systems theory that models how users come to accept and use a technology. TAM is proposed by Fred Davis in 1985[25] relying on the Theory of Reasoned Action. TAM is the dominant model used in predicting, testing and validating information technology products and it's widely used in evaluation educational technologies as well[26]. The model suggests that when users are presented with a new technology, two main factors influence their decision about how and when they will use it, notably:

Perceived usefulness (PU) - defined as "the degree to which a person believes that using a particular system would enhance his or her performance".

Perceived ease-of-use (PEOU) - defined as "the degree to which a person believes that using a particular system would be free from effort".

TAM postulates that actual technology usage is determined by intention to use (Behavioural Intention - BI), which in turn, is viewed as being jointly determined by the person's PU and PEOU (See Figure 3).

In a recent study[27], quantitative methods for measuring the User Experience in educational technology are found to be in parallel with TAM3. In another study[28], TAM3 framework was applied to enquire about why existing technology is underutilized in schools and concluded that existing structure and curriculum of the education systems does not afford enough time to incorporate technology into teaching activities. This study also revealed the teacher's age as a factor as well as technical support available.

[25] Davis, F. (1985), A technology acceptance model for empirically testing end-user information systems. Doctoral dissertation, MIT School of Management, Cambridge, MA.
[26] Teo, T. (2009), Modelling technology acceptance in education: A study of pre-service teachers, Computers & Education, Volume 52, Issue 2, Pages 302–312.
[27] Hu, Y. & Huang, R. (2014), The Research on the Measurement of User Experience in Technology Rich Classroom, Proceedings of ICALT 2014, Pages 780-781.
[28] Mosley, V. V. W. (2012), Technology adoption in K-12 education: A qualitative study using TAM3 to explore why technology is underutilized, Doctoral dissertation, CAPELLA UNIVERSITY, Minneapolis, MI.

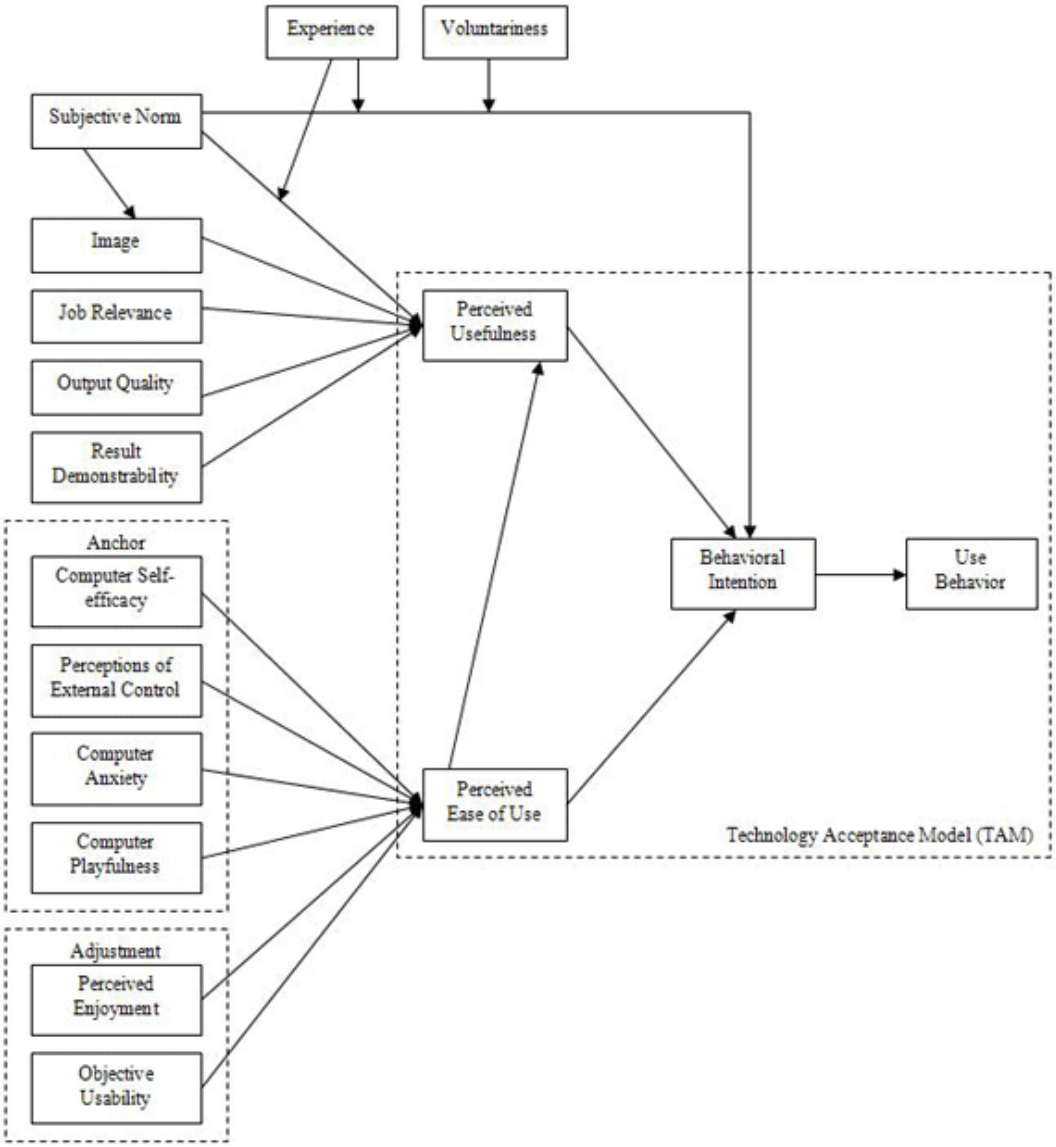


Figure 10. TAM3 concept relations

4.2 ISSM

Ultimately, the aim of evaluation and piloting studies is to inform development partners for making effective progress with the BEACONING system, design updates and implementation. To that end, TAM3 anchors such as image ("Does a user feel like having a higher profile when using BEACONING?"), computer anxiety ("Does BEACONING reduce/increase computer anxiety?") and computer playfulness ("Is BEACONING subjectively Playful?") may not be persuasive or tangible enough for development partners to guide them for developing the system further. If such proves to be the case, it is important to note that the technology acceptance framework can be switched without disturbing the overall

design of a set of evaluation studies to another framework called ISSM (Information Systems Success Model). DeLone and McLean's ISSM identifies and provides general qualities which are thought to enhance user satisfaction. Although TAM3 is used more widely and lead to system related success drivers more directly, ISSM is found to be more conductive in evaluating some educational technologies for further design (e.g. course design Virtual Learning Environments)[29]

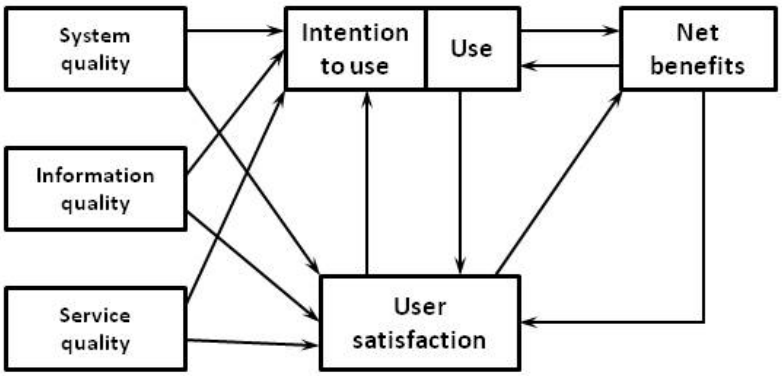
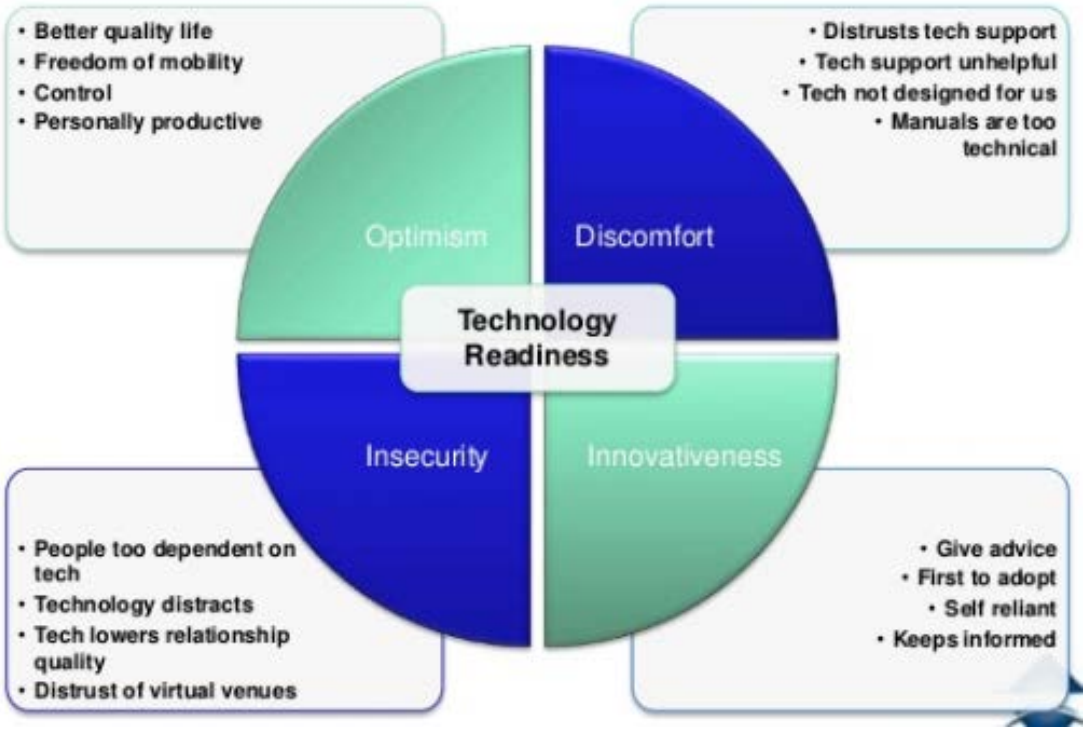


Figure 11. ISSM concept relations

4.3 TRI

Technology Readiness Index (TRI) is developed by A. Parasuraman[30] who is a professor in Marketing at the University of Miami school of Business and one of the most influential figures in the field of services marketing and service quality. The TRI model consists of four constructs (optimism, innovativeness, discomfort and insecurity) which are able to measure an individual's general belief (i.e. readiness) towards new technology. TRI is shown to be suitable for evaluation studies in particular with technology-based services, predicting individual usage behaviour consistently. However, it is found to be not much conductive to further development in cases where teachers are the main end-users[31]. Parasuraman updated the 36-item scale of TRI, given the significant changes in the technology landscape. TRI is updated as TRI 2.0 and streamlined into an analyses that produced a 16-item scale; TRI 2.0's reliability, validity, and usefulness is proven as a customer segmentation tool[32].

[29] Müller, D. et al (2010) Analysis of the Persuasiveness of User Experience Feedback on a Virtual Learning Environment. Proceedings of the First International Workshop on the Interplay between User Experience and Software Development, I-UxSED 2010, Reikjavick, Iceland.
30 Parasuraman, A., (2000). Technology Readiness Index (TRI): A multiple-item scale to measure readiness to embrace new technologies. J. Serv. Res., 2: 307-320.
31 Summak, M.S., M. Baglibel & M. Samancioglu, (2010). Technology readiness of primary school teachers: A case study in Turkey. Procedia-Social Behav. Sci., 2: 2671-2675.
32 Parasuraman, A., and Colby, C. L. (2o15). An Updated and Streamlined Technology Readiness Index. Journal of Service Research. pp. 59-74.



	% of population	Motivators		Inhibitors		TRI
		Optimism	Innovative	Discomfort	Insecurity	
Explorers	27%	4.6	4.1	2.3	2.6	3.9
Pioneers	20%	4.3	4.0	3.7	4.1	3.1
Skeptics	27%	3.7	3.1	2.8	3.4	3.1
Hesitators	14%	4.1	2.1	3.2	3.6	2.8
Avoiders	13%	2.6	1.8	3.8	4.2	2.1
Total		***3.9***	***3.2***	***3.0***	***3.5***	***3.2***

Figure 12. TRI 2.0 concept relations and the segments it can predict

4.4 WHAT WORKS CLEARINGHOUSE PROTOCOLS

As an initiative of the U.S. Department of Education's Institute of Education Sciences (IES), the What Works Clearinghouse (WWC) was created in 2002 to be a central and trusted source of scientific evidence for what works in education. In its public website WWC delivers information from their reviews and findings about a large set of educational products and service. WWC follows a tedious and

scientifically rigorous evaluation protocol. The products that are found to "work" are primed at being on the purchase list of educational districts at once. On "Students with Learning Disabilities Evidence Review Protocol", the WWC reviews focus on interventions for students with learning disabilities in grades K–12 (generally ages 5 to 18) that are intended to improve academic achievement. Outcome areas include reading, math, writing, science, social studies, and progressing in school. The reviews of evidence in this topic area address the following questions:

- Which interventions intended to provide academic skills instruction for students with learning disabilities improve academic achievement in reading, writing, math, science, or social studies, or promote progressing in school?

- Are some interventions especially effective for certain subgroups of students with learning disabilities - for example, students of different ages, students with particular types of learning disabilities, students of different racial/ethnic groups, or English Language Learners (ELLs)?

4.5 BEACONING REFLECTION

BEACONING evaluation studies are not aimed at measuring whether learning has happened. The purpose of the BEACONING pilot studies is to build a model that predicts the level of technology acceptance by authors (learning designers), teachers and students. We will examine the relationships among variables associated with factors that influence technology acceptance. Data will be collected through survey questionnaires and structured dialogues with both teachers and students. Employing structural equation modelling, a set of predictions will be made about the actual end-user behaviour to test the model fitness.

5 CONCLUSION

This review report comprises an analysis of the game-based education market, various challenges and opportunities therein, as well as a discussion about how gaming helps to implement inclusive education. A selection of evaluation frameworks is also covered since such evaluation of BEACONING trials and pilots is to guide the project work towards exploitation in the aforementioned markets.

As the market analysis spirals through a large diversity of applications and developments in the field, it gradually becomes clear that there is a shift in using so called "serious" or "educational" games by individual students to an understanding of the "value of playfulness" in learning[33]. Captured in the phrase "education as a game" this trend points at a new mindset in formal education. Until today, class time in formal education is mostly spent for "deductive" activities where students apply the general knowledge that the teacher delivers to specific situations as practice or homework. Game-based learning as well as enquiry based learning or project based learning, introduce "inductive" activities where students integrate the knowledge they acquired mostly by trial and error to develop the general knowledge themselves. Essentially, this is not an alternative path of education, but rather a complementary one, since the human mind has evolved to reason both inductively and deductively, often circulating both modes to have a grasp, an understanding of the subject matter. Phenomenological philosophies increasingly dominate educational models[34] as the world industries demand more innovative, self-authoring and self-regulating employees who are able to generate new knowledge, or new understandings. Hence, active learning prevails learning designs, especially in higher education[35] and increasingly trickle down to K12 grades. This high level trend in the world of education fuels subject-specific game development, educational game portals and a new generation of start-up companies. As the "first-person" experiencing of learning better understood, new concepts such "education as a game" or "learning as play" or even "learning as an experience of freedom[36]" will be in research agendas at first and then, perhaps in the agendas of educational leaders.

This "Tech Watch" deliverable will be refined/updated and delivered again in Month 24.

[33] Whitton, N. (2014). Digital games and learning: Research and theory. p. 189
[34] Selvi. K. (2008). Phenomenological Approach in Education. In Tymieniecka A.-T. (Ed.) *Education In Human Creative Existential Planning*. pp 39-51
[35] Waldrop, M (2015). "The Science of Teaching Science," Nature, Vol 523, pp 272-274
[36] Yun, SI; (2016) *A Concept of Education in the Experience of Freedom: Hermeneutic-Phenomenological Investigations*. Doctoral thesis, UCL (University College London).ra