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Virtual Worlds

IMMERSIVE ONLINE PLATFORMS FOR COLLABORATION, CREATIVITY AND LEARNING

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Working Party on the Information Economy

VIRTUAL WORLDS - IMMERSIVE ONLINE PLATFORMS FOR COLLABORATION, CREATIVITY AND LEARNING

Immersive online platforms for collaboration, creativity, and learning

English - Or. English

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FOREWORD

This report provides an overview of the potential benefits but also limitations of virtual worlds for enhancing collaboration, creativity, and learning, and thus improving innovation performance across society. The report shows to what extent virtual worlds provide platforms for new and experimental interactions and can thus be considered a catalyst behind the changing nature of innovation, as discussed in particular in the *OECD Innovation Strategy*.

The report draws on the results of the *United Kingdom-OECD Workshop on Innovation and Policy for Virtual Worlds* hold in March 2009 and the conference *Virtual Policy '08* organised by the United Kingdom Department for Business, Enterprise and Regulatory Reform in July 2008. It also benefits from the results of the *OECD-Canada Technology Foresight Forum on the Participative Web* hold in October 2007, as well as on previous OECD work on digital content including in particular on the participative web and user-created content as well as on online computer and video games.

This report was first presented to the OECD Working Party on the Information Economy (WPIE) in December 2009 as part of its work on *Networked ICTs and Innovation*. It was declassified by the OECD Committee for Information, Computer and Communications Policy (ICCP) in October 2011.

The report was prepared by Mr. Christian Reimsbach-Kounatze of the OECD Directorate for Science, Technology and Industry (STI). It is published under the responsibility of the Secretary-General of the OECD.

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SUMMARY

Virtual worlds are increasingly evolving into Internet-mediated "spaces", where large groups of people meet and interact in real-time while experiencing a shared sensation of being there together. This enables richer and more dynamic social interaction and collaboration across national and cultural boundaries over the Internet compared to other traditional ICT-based collaboration environments (including web 1.0 and 2.0 platforms such as websites, wikis, blogs and even social networking sites). Many virtual worlds also empower users to create virtual items (User Created Content, UCC) in collaboration and to exchange these virtual assets for virtual or real-life currencies. In this report, a virtual world is defined as *a persistent computer-simulated environment allowing large numbers of users, who are represented by avatars, to interact in real-time over a computer network such as the Internet*.

There are a number of promising examples showing the benefits of using virtual worlds in *i)* entertainment and social networking, *ii)* education and training, *iii)* e-commerce and e-business; *iv)* research and development, *v)* tele-working and tele-conferences; and *vi)* e-government and public sector information. Despite these benefits, limitations and challenges remain.

Entertainment and social networking still represent by far the most significant application of virtual worlds in terms of number of users and market volume. More than 70% of virtual world users are using worlds mainly dedicated to entertainment or social networking. The market for virtual worlds for gaming (*i.e.* Massively Multiplayer Online Games, MMOGs) is the second largest software game market worth around USD 7 billion in 2008 (accounting for almost 20% of the total computer game market in 2008). MMOGs are growing the fastest in Asia, which with an estimated value of more than USD 3 billion made up almost half of the global MMOG market in 2008. Europe and the United States follow; with an estimated market value between USD 2 billion and USD 3 billion each.

Virtual worlds are attracting a significant volume of real economic transactions of virtual goods and services between consumers (consumer-to-consumer, C2C) as well as between businesses and consumers (business-to-consumer, B2C). The total market for virtual items created and exchanged between users was worth roughly USD 5 billion in June 2010 and the value is expected to more than double within the next two years. The Asian market is the largest with almost USD 4 billion being generated in 2009. A wide range of real-life firms such as IBM, Reuters, Telecom Italia, and Toyota are active in virtual worlds such as *Second Life*, although there has been a notable stagnation in the engagement of new firms during the financial and economic crisis. The involvement of businesses in virtual worlds varies considerably; ranging from using virtual worlds as an additional marketing environment to hosting recruitment fairs, virtual conferences, training sessions, and collaborative research and development (R&D).

Education and training seem to be the most promising application area for virtual worlds. To date, over 150 universities have a presence in the virtual world *Second Life* or other virtual worlds. There are a number of factors that have led to high rates of adoption in universities and other educational institutions. These include face-to-face and group interaction between students and educators around the world (including in developing countries), access to resources and knowledge, voice communication, and examination of abstract and complex models through 3D visualisation or projections of visual information. Virtual worlds also provide realistic and interactive role-playing simulations for training situations. The

U.S. National Institutes of Health, for example, is using virtual worlds for emergency and disaster research and training.

Virtual worlds enable researchers, businesses and end-users to carry out collaborate in research and in development of new products and services. As is the case for education and training, the benefits of using virtual worlds for research and development come from *(i)* 3D visualisation and projections of visual information; *ii)* a closer and richer interaction between researchers, businesses and end-users (in real-time); and also *iii)* the empowerment of end-users to actively create UCC together with others. Toyota, for example, used *Second Life* to prototype the *Toyota Scion*, during which user through their avatars could discuss, evaluate, modify, and further develop the model.

The adoption of virtual worlds brings environmental opportunities resulting from their ability to dematerialise processes in households, businesses and governments. Most of all this includes the substitution of travelling and commuting, since people can meet in virtual worlds and still experience a sensation of "being there". Conferences and meetings completely hosted in virtual worlds such as *The Virtual World Conference* in *Second Life* are prominent examples of how virtual worlds can reduce environmental impacts across society while also saving *e.g.* travelling costs. Thus, virtual worlds can be an ally in combating climate change and enabling *green growth*.

Virtual worlds also provide opportunities for the public sector to enhance its e-government services and public sector information (PSI). These include in particular *i)* increasing citizen participation among Internet users; and *ii)* providing public sector information (PSI) in a media-richer and interactive way. The Spanish Society for the Management of Innovation and Technology in Tourism (SEGITTUR), for example, is developing a 3D virtual world for promoting tourism in Spain, where high resolution images from the Spanish National Geographic Institute as well as aerial images and videos of geographic attractions will be interlinked.

Broadband, game technologies and demographic factors have been identified as the main drivers of virtual worlds. Rapidly increasing bandwidth has helped spur the adoption of virtual worlds. In addition, game technologies such as game middleware, 3D graphics and real-time interactivity will drive development. The game industry thus continues to be the main source for technological spillovers. Furthermore, the adoption of virtual worlds still remains dependent on the age of users, with the younger population, and in particular boys, still being the most active user group in virtual worlds. However, there is evidence that virtual worlds may increasingly attract girls and women.

There are a number of barriers and challenges, however, which need to be addressed to ensure the adoption of virtual worlds. Many of these challenges such as intellectual property rights (IPR) are not specific to virtual worlds, but rather a common challenge of internet platforms and of the collaborative web in particular. Other policy challenges, however, have intensified with the diffusion of virtual worlds. These include issues such as increasing requirements on broadband networks, lack of interoperability and standards between different virtual worlds, increasing skill requirements for developers and end-users alike, but also some regulatory issues such as the increasing risks of online addiction, the increasing significance of in-world transactions for taxation, and classification and measurement issues.

VIRTUAL WORLDS: IMMERSIVE ONLINE PLATFORMS FOR COLLABORATION, CREATIVITY AND LEARNING

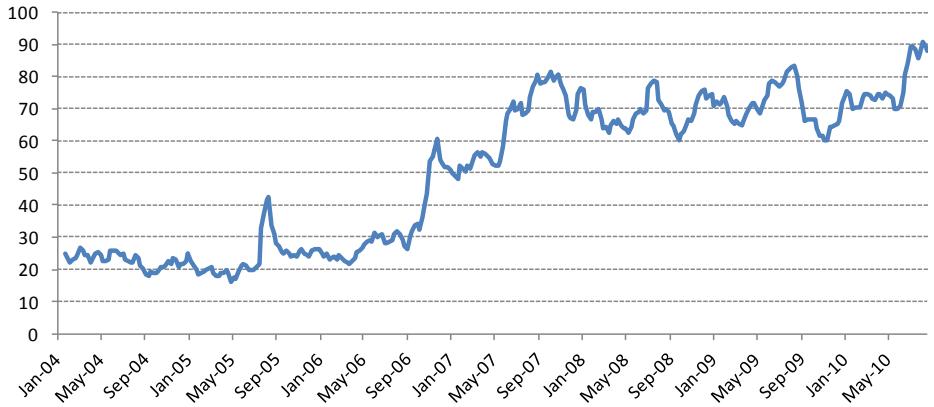
Introduction

Virtual worlds increasingly present a range of opportunities to citizens, businesses and governments, including richer social interactions, improved business processes, and accelerated research activities. As well as being a very successful segment of the entertainment and computer games industry, virtual worlds have evolved as Internet-mediated 'spaces', where large groups of people meet and interact in real-time for learning, scientific research, health care, defence and further areas other than entertainment only (*i.e.* "serious" games)[1] (see Bartle, 2006; Balkin and Noveck, 2006; Messinger *et al*., 2008). The diffusion of virtual worlds has been supported directly or indirectly by the development of powerful and affordable computing devices with better and faster graphic processing units (GPUs), underpinned by the rapid diffusion of high-speed broadband.

However, the adoption of virtual worlds has been moderate since the beginning of 2008 compared to the hype and the positive predictions related to virtual worlds such as *Second Life*.[2] In addition, the financial and economic crisis has forced the virtual world industry to undergo notable consolidation, with providers such as Makena Technologies (United States-based provider of virtual world *There.com*) discontinuing its virtual world service or Suelake (Finland-based provider known for *Habbo*) merging their different country specific virtual worlds.[3] There are some indications, however, that the interest in virtual worlds is regaining momentum, as suggested by the analysis of user-to-user transaction volume in virtual worlds as well as search activities on search engines such as google.com (see Figure 1)[4] Furthermore, top Information and Communication Technology (ICT) firms, such as Intel and Nokia, continue to invest in virtual world technologies.[5] As Messinger *et al.* (2008) have pointed out, "despite receptive coverage in the press, it is not yet entirely clear, however, what values virtual worlds add to more traditional e-commerce and e-government, or how organizations and individuals can harness this value".

Figure 1. Weekly web search interest for "virtual world" on google.com, 2004-2010

Index 01-07 August 2010 = 100 , 4-weeks moving average



Note: The index indicates the likelihood of a random user searching for the term "virtual worlds" at a certain time.

Source: OECD based on Google Insights for Search *(www.google.com/insights/search/#q=%22virtual%20world%22)*

Approach and structure

The *Seoul Declaration for the Future of the Internet Economy* of June 2008 invites the OECD to analyse the future development of the Internet Economy, and explicitly mentions virtual worlds as one of the "emerging Internet technologies, applications and services" to be analysed (see OECD, 2008b). This report will provide an overview of the potential benefits but also limitations of virtual worlds for enhancing collaboration, creativity, and learning, and thus improving innovation performance across society.[6] The report will show to what extent virtual worlds provide platforms for new and experimental interactions and can thus be considered a catalyst behind the changing nature of innovation, as discussed in particular in the *OECD Innovation Strategy* (see OECD, 2010a).[7] The report will also examine the main drivers as well as barriers and challenges for the diffusion of virtual worlds. Given the lack of widely available data on virtual worlds, with the exception of virtual worlds as entertainment applications, this report is based on the analysis of use cases and examples of virtual world applications that have been discussed in the literature.

The report will be structured as follows: after developing a working definition and a typology in the next section, this report will present the main fields of application of virtual worlds that appear to be the most promising based on available data or use cases analysed. These include:

1. Entertainment and social networking
2. E-commerce and e-business
3. Education and training
4. Tele-working and tele-conferencing
5. Research and development
6. E-government and public sector information.

The report will then highlight the main drivers of, growth and barriers to, virtual worlds, based on the analysis of these use cases. Finally, this report will draw a conclusion based on the analysis presented.

Definition and typology

The history of virtual worlds can be traced back to the 1970's, where the term "virtual world" was already used by the scientific community and other experts; mainly in the context of *virtual reality* or *computer games* (see Burdea and Coiffet, 2003; Bell, 2008; and Sivan, 2008). With the rising popularity of virtual worlds such as Linden Lab's *Second Life* and Blizzard's *World of Warcraft*, the term "virtual world" became more popular. However, there is still no single agreed-upon definition for "virtual world", and literature review reveals that the term is being used in different ways at different times by scholars, industry professionals, journalists and policy makers (see for example Bell, 2008; Sivan, 2008; Schroeder, 2008; OECD, 2009). This section will present a working definition for virtual worlds after a brief review of existing definitions. It will also develop a typology to classify and distinguish the different types of virtual worlds as well as those environments classified as virtual worlds in literature contrary to this report.

Definition

Common in most definitions is that a virtual world provides a *computer-based environment for large numbers of users*. Castronova (2005), for instance, defines virtual worlds as "crafted places inside computers that are designed to accommodate large numbers of people". However, as Bell (2008) has pointed out, "using Castronova's definition, a chatroom or a shared document would be a 'virtual world'". Some authors have therefore highlighted that a virtual world should in addition be based on a *virtual reality* environment, that is "a high-end user computer interface that involves real time simulation and interactions through multiple sensorial channels" (Burdea and Coiffet, 2003).[8] However, the virtual environment does not need to be a 3-dimensional (3D) environment; a 2-dimensional (2D) or textual environment would also satisfy the above criteria, as long as the environment is computer-simulated and allows real-time (*i.e. synchronous*) interaction between large numbers of users and the simulated environment.

In addition, some authors such as Koster (2004) and Reeves *et al.* (2008) have emphasised that virtual world environments should be *persistent*, *i.e.* they should continue to exist and function even after the users have left. Koster (2004), for example, defines a virtual world as "a spatially based depiction of a persistent virtual environment, which can be experienced by numerous participants at once, who are represented within the space by avatars". Under this condition, multiplayer games such as, for instance, Valve's first person shooter (FPS) *Counter-Strike* or Blizzard's real-time strategic game *StarCraft*, which only exist during a game session, are not considered virtual worlds.

The definition provided by Koster (2004) also points to another requirement for the existence of virtual worlds, namely the *avatar*, without which "a virtual world would be an empty data warehouse" (Bell, 2008). According to some authors such as, Matchett (2000) or Sivan (2008), the term "avatar" originated from the Hindu philosophical term *avatāra*, meaning "incarnation" or "appearance" and "manifestation".[9] In the context of virtual worlds, the term "avatar" refers to the digital (graphical) representation of the user within the virtual world. The avatar is thereby more than just a simple label or name. It "has agency (an ability to perform actions)" and "is controlled solely by a human agent in real time" (Bell, 2008). Thus, virtual worlds are distinguished from social network sites such as *Facebook* and *Myspace*, which, despite having a persistent environment, do not provide an avatar for their users.[10]

For the purpose of this report, a virtual world is defined as a persistent computer-simulated environment allowing large number of users, who are represented by avatars, to interact in real-time with each other and the simulated environment.[11] This report will assume virtual worlds to be accessible over a computer network such as the Internet. Table 1 summarises the list of criteria included in the above definition and provides a list of negative examples, *i.e.* environments that are sometimes classified as virtual worlds in literature, but would not be classified as such in this report (see also Annex Table 1 for a comprehensive list of positive examples).

Typology

The above definition includes a set of virtual worlds that can be differentiated according to the following four criteria: *i)* the main target group (*e.g.* by age or gender); *ii)* the type of objective (*i.e.* developer-defined objectives or user-defined objectives); *iii)* the degree of user-created content (UCC)[12] (ranging between developer-created content only to user-created content only); *(iv)* the degree of openness (ranging from *public* virtual worlds such as Second Life to *private* virtual worlds such as *Forterra Systems' OLIVE*). These four criteria influence the possible fields of applications for virtual worlds as will be shown in the next section. In particular, it will be shown that the type of objective defines whether virtual worlds are online games or social virtual worlds, and that the degree of UCC and the

degree of openness are crucial for the successful adoption of virtual worlds across all fields of non-pure entertainment applications ("serious" games).[13]

Table 1. Criteria for virtual worlds and negative examples

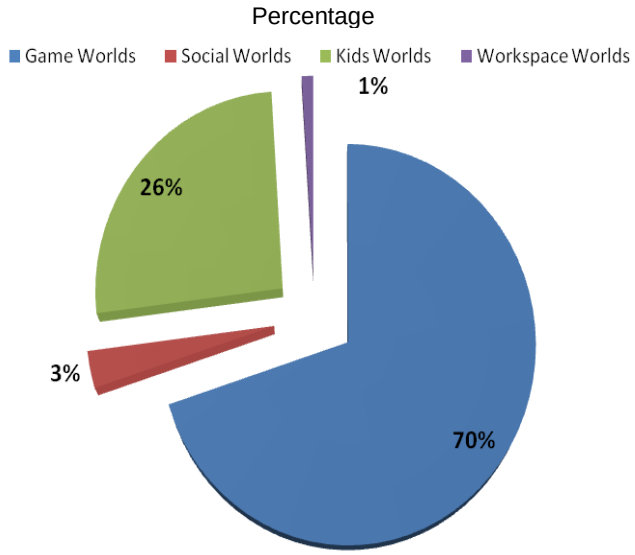
Criteria	Negative examples
Computer-simulated environment	Fantasy role-playing games such as Wizards of the Coast's *Dungeons and Dragons*
Multi-user environment	Single-user open world games such as Rockstar Games' *Grand Theft Auro (GTA)* series or Electronic Arts (EA)' *The Sims* series
Real-time (synchronous) interaction	Shared documents, and …
Avatar	… virtual reality maps such as Google Earth, virtual meeting software, social network sites
Persistent world	Online multiplayer video games such as Blizzard's real-time strategy game *StarCraft* or Valve's first person shooter *Counter-Strike*, virtual reality environments, for instance, of Computer-Aided Design (CAD) software.

Fields of application of virtual worlds

Virtual worlds are interactive platforms for entertainment but also for learning, scientific, defence, health care and further "serious" applications. The benefits of virtual worlds come to a large extent from the use of game technologies such as real-time interactivity and 3D graphics. Therefore, virtual worlds can hardly be distinguished from pure-entertainment online games from a technical point of view. This is one of the reasons why measuring the deployment of virtual worlds in non-entertainment areas still remains a challenge.

For instance, available data on the number of worldwide users of virtual worlds by main target group suggest that the large majority of users (more than 70% of worldwide users) are using virtual worlds mainly dedicated to entertainment or social networking (see Figure 2).[14] However, these numbers have to be interpreted carefully, given the possibility to use the same virtual worlds for applications other than entertainment only. For example, while a set of users may only be playing for fun, another set of users in the same virtual world may be learning or doing research. With advances in consumer hardware processing power and in the diffusion of ultra-fast broadband, the serious use of virtual worlds can be expected to intensify and expand.

Figure 2. The share of users of virtual worlds by main target group



Source: Imagine Venture

The following sections will present available data and use cases of the main and most promising fields of virtual world applications, namely: *i)* entertainment and social networking; *ii)* education and training; *iii)* research and development; *iv)* e-commerce and e-business, and *(v)* e-government and public sector information.

Entertainment and social networking

In terms of number of users, entertainment and social networking represent by far the most significant applications of virtual worlds. The two main types of applications that are considered in the following include: *i*) *Massively Multiplayer Online Games* (MMOGs); and *ii*) *Social Virtual Worlds* (SVWs). One of the main determinants defining whether a virtual world is a MMOGs or a SVW is the type of objective of the world, whether it be gaming or socially focused.

Massively Multiplayer Online Games

MMOGs are the most prominent application of virtual worlds. MMOGs are games played over the Internet with, in some cases, more than 10 000 players playing at the same time and more than 1 million players registered (see OECD, 2005).[15] Players in MMOGs can co-operate and compete with each other in real-time through their avatar to reach their game objectives. MMOGs – the most developed are the Massively Multiplayer Online Role Playing Games (MMORPGs, see Box 3 for an example) – are different from traditional online games, as they do not have a beginning or end, but instead provide a *persistent but evolving virtual reality environment*, in which players come and go. Thus, MMOGs are virtual worlds according to the working definition proposed in this report. Like traditional online games, however, MMOGs have a pre-defined back story with a set of pre-defined objectives, and in most cases the game universe is mainly created by the game designers, with limited possibilities for UCC.

Box 1. What is an MMORPG? The example of *Age of Conan*

Age of Conan is a MMORPG based on the fantasy world of *Conan the Barbarian*. It has been developed by Funcom, a Norwegian developer and publisher best known for its science fiction MMORPG *Anarchy Online*. In the beginning of 2009, Funcom employed 302 people with 120 employees primary developing *Age of Conan*. Over 1.2 million copies were sold during the first three months after its release in May 2008, making it the fifth largest MMORPG after *Lineage I* and *II* (by Korea-based company NCsoft).

In *Age of Conan*'s fantasy virtual world of 3D-graphics and sound, thousands of players can compete and collaborate simultaneously in an evolving background story updated with new releases and in response to in-game character actions. In the game itself, players co-operate to battle adversaries or sell services for cash and equipment, engage in virtual recreation activities, etc.

The game already has an online community, active through fan-sites and societies. Earnings come from sales of boxed (or downloaded) software at USD 19.95 – 29.95 for different versions and monthly subscriptions from USD 12.99 - 14.95. Funcom's online business model is based on long-term players who pay subscription fees, on average, for 10 months, enabling them to release sequels, to promote the brand, and to expand the associated game community involvement.

Source: Annual and quarterly reports of Funcom

MMOGs are a rapidly growing entertainment industry characterised by intense competition and global scope, as well as significant network and lock-in effects (see Selwyn, 2007; Pannicke and Zarnekow, 2009). The total number of active users worldwide playing MMOGs was estimated to be more than 17.5 million at the end of 2008, with *World of Warcraft* accounting for more than 65%, and continuing to grow rapidly. In many cases users pay a retail price for the boxed (or downloaded) software ranging between USD 10 and USD 20 for the most basic versions and a monthly subscription ranging from USD 10 to USD 15 (see Table 2).[16] But other business models have also been adopted such as prepaid and micro-payment or in-world advertisement by third-parties (see OECD, 2005).

As a consequence, the market for MMOGs became the second-largest software game market (almost 20% of the total computer game market in 2008); still far behind that for offline console games (accounting for slightly less than 60% of total game market in 2008), but still ahead of the market for wireless games (less than 15% of total game market in 2008).[17] Online games and MMOGs in particular are the fastest growing game segment, overtaking the PC-offline market (accounting for 10% of total game market in 2008) for the first time in 2005. In 2008, revenue from MMOGs was estimated to grow by more than 20% to reach a value of around USD 7 billion, contributing significantly to the growth of the software industry. MMOGs are growing the fastest in Asia, which with an estimated value of more than USD 3 billion made up almost half of the global MMOG market in 2008 (see *PwC*, 2007). Europe and the United States follow; with an estimated market value between USD 2 billion and USD 3 billion each.

Table 2. Selected MMORPG prices, USD

Game	Developer	Publisher	Retail price[1]	Monthly charge[2]
World of Warcraft	Blizzard	Vivendi Universal	19.99	14.99
Anarchy online	Funcom	Funcom	Free	Free
Age of Conan	Funcom	Eidos	19.95	12.99
Asheron's Call (I&II)	Turbin	Microsoft	19.99	12.95
City of Heroes	Cryptic Studios	NCSoft	12.99	14.99
EverQuest II	Sony Online Entertainment	Sony Online Entertain.	14.49	14.99
Lineage II	NCSoft	NCSoft	19.99	14.95
Star Wars Galaxies	Lucas Arts	Sony Online Entertain.	15.99	14.99
Ultima Online	Origin	Electronic Arts	Free	12.99

1) Only includes the most basic version, as retail price may differ depending on the version. For example, the basic version of *World of Warcraft* can be purchased for USD 19.99. In contrast, *World of Warcraft Battlechest,* which includes the first expansion pack *Burning Crusade* as well as the basic version, costs USD 36.99.

2) Only includes monthly charges for the subscription with the shortest duration. For example, a month-to-month package for World of Warcraft costs USD 14.99 per month, but a three-month package USD 13.99 per month, and a six-month package USD 12.99 per month.

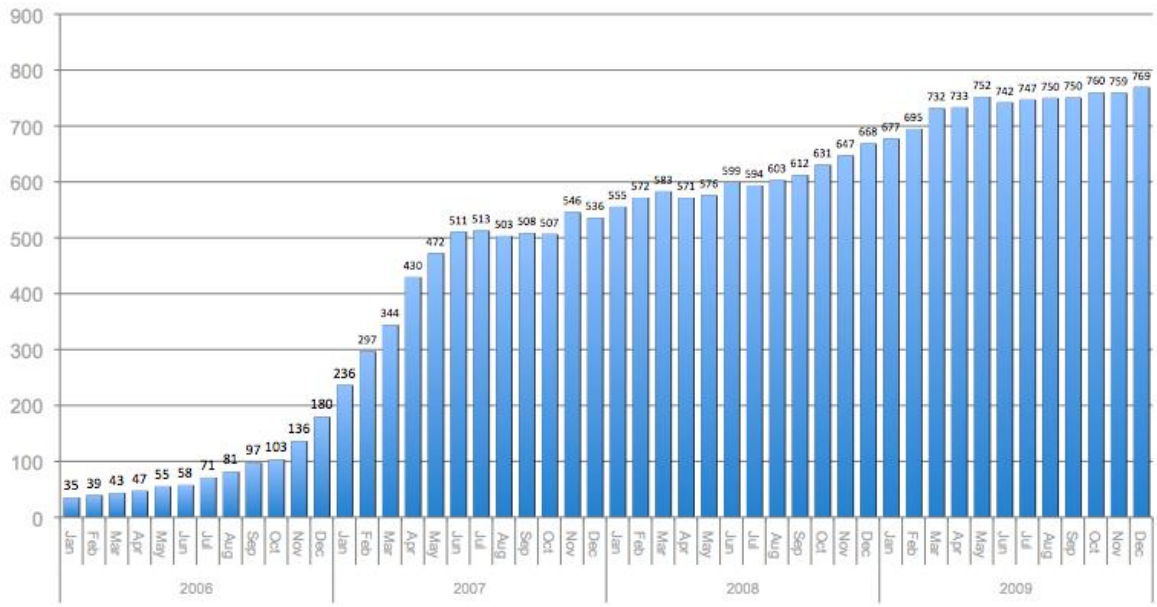
Virtual Social Worlds

VSWs are virtual worlds which, unlike MMOGs, are not based on "structured, mission-oriented narratives" and explicit goals (Reeves *et al.*, 2008). Instead, VSWs are mainly building on user creativity and collaboration, thus allowing the users to define their universe, rules and objectives, as well as to create digital objects and landscapes that surround them. VSWs are sometimes also referred to as "metaverses" (Stephenson, 1992) or "real virtual worlds" (Sivan, 2008), because of the freedom (*e.g.* to generate UCC) they provide. As will be shown in the following sections, it is in particular this freedom that favours the dominant adoption of VSWs for "serious" applications.

The most popular VSW is Linden Lab's *Second Life*, which now counts more than 15 million registered users[18], and around 800 000 active users (see Figure 3). In *Second Life*, users collaborate with each other to create the virtual environment. User creations range from single virtual items to virtual businesses and shopping malls. These businesses, in turn, can offer virtual products and services (see section below). Other examples for VSWs include among others: *Habbo Hotel* (Finland), *Blue Mars* and *Twinity* (United States), and *HiPiHi* (China) (see Annex Table 1 for a comprehensive list of virtual worlds).

Figure 3. Monthly unique users with repeat logins in *Second Life*, 2006-09

In thousand



Source: *Linden Lab (http://blogs.secondlife.com/community/features/blog/2009/04/16/the-second-life-economy--first-quarter-2009-in-detail)*

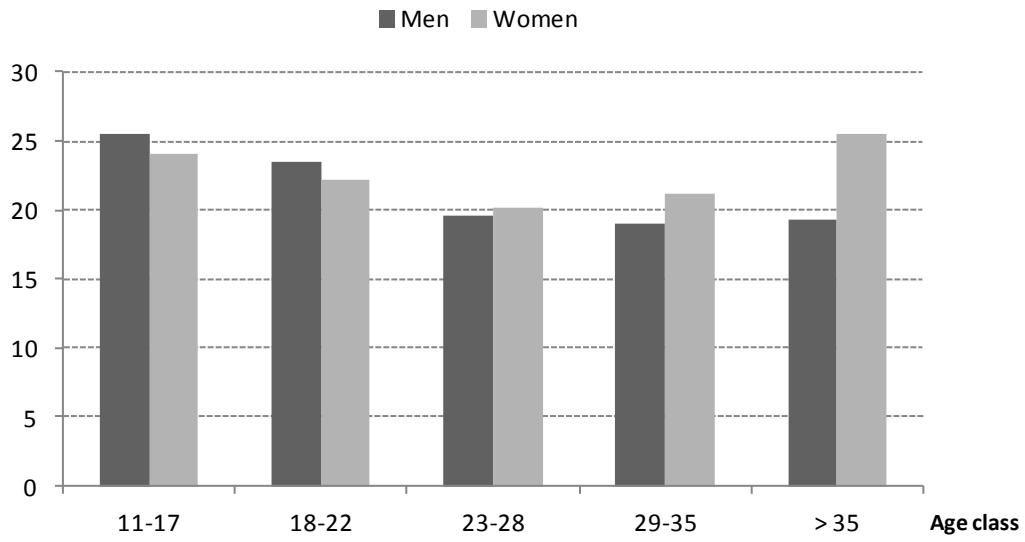
Limitations and challenges

The increasing adoption of virtual worlds for entertainment and social networking and in particular MMOGs also raises some serious challenges however. This includes most of all the excessive use of virtual worlds, increasing the risk of online addiction, but also introduces questions related to taxation, which are discussed later in this paper.

There is ongoing debate on the impacts of intensive use of the Internet in causing "online" addiction, an issue already well known in the context of the traditional web (including web 2.0) (see OECD, 2005). The advancing ability of virtual worlds to create immersive virtual reality environments is increasingly blurring the boundaries between real and virtual worlds and thus may intensify the risks of online addiction (see Xing, 2007; Sang-Hun, 2010). This may lead users to increase their time online, to the extent that they may fail to devote enough time to other obligations (*e.g.* school, work, family, and even sleeping and eating).

The increasing time spent by users is sometimes taken as an alarming signal. According to a survey done by Yee (2005b), users spend significant time in virtual worlds: adults up to 21 hours per week on average and teens up to 25 hours per week, and this has increased over the last years (see Figure 4). In *Second Life*, for instance, the average hours spent per week is less than the total average; but still has increased by 16% from 13 hours in Q1 2008 to 15 hours Q1 2009. In Q1 2010, however, there was a decrease by 19% to 12 hours a week spent by the average *Second Life* avatar. Overall, it should be noted, that such intensive use is not particular to virtual worlds, but relates broadly to how people decide to manage their media usage habits (including media such as TV, smart phone, and the Internet in general). Users who engage more actively in virtual worlds may have previously been watching TV in a passive fashion, and they may now be creating and maintaining (real) social relationships with others through virtual worlds.

Figure 4. Average hours spent in virtual worlds by age class and gender



Note: Based on a sample of 1 587 men and 379 women.

Source: OECD based on Yee (2005b)

Besides the immersive nature of virtual worlds, two psychological *attraction factors* have been highlighted to also increase time investment and personal attachment in virtual worlds and MMOGs in particular. These are: *i)* the network of relationships that is accumulated over time; and *ii)* the elaborate rewards cycle inherent in particular in MMORPGs (see Yee, 2002). Virtual worlds are places for collaboration, thus favouring the creation of social networks. The social bonds created within these networks are further intensified due to the entertaining or sometimes even stressful situations collectively experienced in virtual worlds. Yee (2002) has also emphasised that "[t]he anonymity and computer-mediated chat environment facilitates self-disclosure", which in turn also increases the social bonds. As he adds, "[t]hese relationships can then be so strong, and many players have told personal issues or secrets to online friends that they have never told their real life friends or family".

Furthermore, the *elaborate rewards cycles*, which are specific for MMORPGs in particular, works "like a carrot on a stick", exponentially increasing the incentives to stay active in the virtual world. These in turn intensify the emotional attachment to virtual worlds. Rewards are given to players very quickly in the early stage of a MMORPG, but become exponentially more difficult to obtain over time. For example, while it usually takes only 5-10 minutes of play time to initially increase the characteristics of an avatar in *World of Warcraft*, for an advanced avatar the time required for an increase can grow to up to 20 hours of game time. These attachments (to online friends as well as to the virtual environment itself) may lead to a deterioration of relationships outside of the Internet, and thus favour the occurrence of online addiction. Some OECD governments have established measures to tackle these specific risks for and impacts of online addiction (see section below on policy opportunities and challenges).

E-commerce and e-business

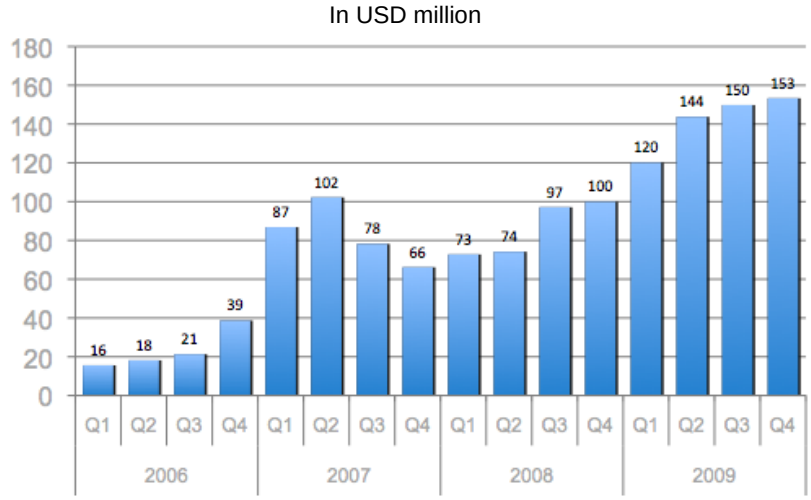
Increasingly, virtual worlds are becoming platforms for real economic transactions. This includes transactions between consumers (consumer-to-consumer, C2C) as well as between businesses and consumers (business-to-consumer, B2C). Users create, sell and purchase virtual properties including land and objects. Sometimes these commercial transactions take place within the virtual world, sometimes outside of it (*e.g.* selling virtual objects via online auction sites such as eBay). Increasingly these virtual worlds have a significant economic importance (in terms of revenues generated and transacted) and

corresponding real-life impacts (see Castronova, 2005, or example presented above). According to KZERO, a consulting company focussing on virtual worlds and virtual goods, the total market for virtual items created and exchanged between users was worth around USD 5 billion in June 2010 and the value is expected to more than double within the next two years. The Asian market is the largest with around USD 3.8 billion being generated in 2009.

A wide range of real-life firms such as Circuit City, IBM, Reuters, Telecom Italia, and Toyota are active in virtual worlds such as *Second Life*[19], although there has also been a notable stagnation in the engagement of new firms in virtual worlds during the crisis. The involvement of businesses in virtual worlds varies considerably: Some businesses see virtual worlds as an additional marketing environment in which to place their brand and (digital) equivalents of their real life products (*e.g.* communication services, consumer electronics, cars) and some have also opened virtual shops for their virtual products. For example, Canada's IMAX Corporation advertised the fifth part of the Harry Potter-saga within *Second Life* and managed to contact 150 000 visitors. This is cheaper and more effective than more traditional means of online advertising. According to the French market research firm *Repères*, the cost of a virtual qualitative focus group is about 33% lower and quantitative surveys could be conducted at half the cost of a comparable real life project (Kaplan and Haenlein, 2009). Some firms and organisations are going further and are using virtual worlds for other activities related to their business. This includes but is not limited to hosting recruitment fares, virtual conferences and training sessions.

Overall, users continued to increase their e-business and e-commerce activities in virtual worlds in 2010, although at a much slower pace than in previous years. The total world size of *Second Life*, for instance, which describes how much virtual land has been bought by users looking for new virtual land to host or extend their virtual presence, reached 1 848 billion square meters in 2009, a 7% increase over 2008 and an almost 88% increase over 2007. In the first quarter of 2010, "resident-owned" land expanded to reach 1 903 square kilometres (15% more than in the same quarter last year).[20] The total value of user-to-user transactions in *Second Life*, as another indicator, grew from USD 344 million in 2008 to USD 567 million in 2009; an increase of 65% (see Figure 5). In Q1 2010, growth in total user-to-user transaction value slowed to 33% compared to Q1 2009, an effect most likely associated with the financial and economic crisis.

Figure 5. Total value of quarterly user-to-user transactions in *Second Life*, 2006-09



Source: Linden Lab (blogs.secondlife.com/community/features/blog/2009/04/16/the-second-life-economy--first-quarter-2009-in-detail)

Limitations and challenges

There are some limitations and challenges associated with using virtual worlds for e-commerce and e-business, most of all the costs. A presence in a virtual world often requires firms (and other organisations) to "buy" virtual land and to build a virtual site. For example, "buying" an island in *Second Life* (*i.e.* a full region of 65 536 m^2 of virtual land) requires paying an initial price of USD 1 000 and a monthly (maintenance) fee of USD 295.[21] But there are additional costs, including for example for virtual building design and maintenance, and the entertainment of visiting avatars. As Rose (2007) described, "[a] company can stage an in-world speaking event for as little as [USD]10 000, but hiring Electric Sheep or one of its competitors to create a full-time presence, with a private island and a lot of virtual construction, could run several hundred thousand [USD] a year".[22]

Education and training

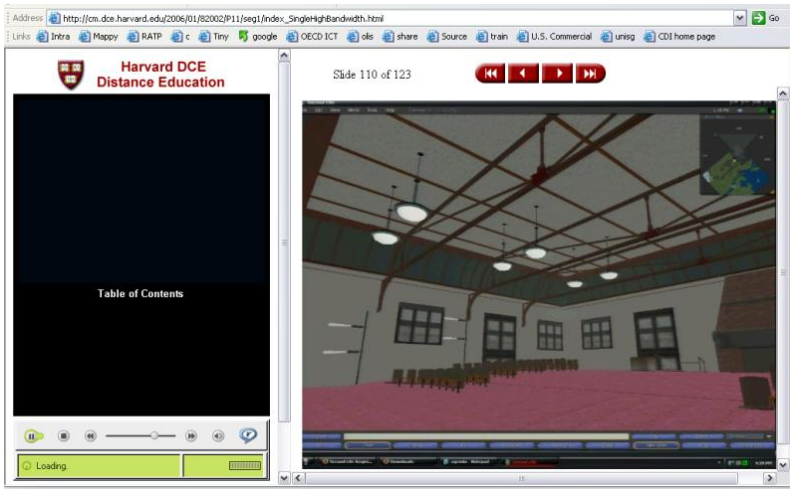
Virtual worlds and in particular SVWs are also being used to support education and training in the private and public sectors. This includes organisations as diverse as education, health care and security and defence institutions. In this section, public virtual worlds such as *Second Life* or private virtual worlds such as Forterra Systems' *OLIVE* are presented as tools for: *i)* education and e-learning; and *ii)* simulations based training.

Education

Virtual worlds, particularly because of their interactive nature, can provide useful tools for education. The benefits of virtual worlds for education come from the use of online game technologies (*e.g.* multiplayer platforms, increased interactivity, and 3D visualisation) enabling richer and more dynamic social interaction and collaboration between large numbers of users over the Internet. Furthermore, virtual worlds provide a new platform for gaining experience in devising educational tools (see for instance O'Connell *et al.*, 2008). Research initiatives such as the Education Arcade (educationarcade.org), a consortium of international game designers, publishers, scholars, educators, and policy makers investigating the educational potential of video games to be used in education, have shown that there are benefits from using game technologies in education.[23]

To date, over 150 universities have a presence in *Second Life* or other virtual worlds (see Foster, 2008).[24] These include: the University of Florida, Princeton, Vassar, the Open University (UK), Harvard, Australian Film Television and Radio School, Stanford, Delft University of Technology, and AFEKA Tel/Aviv Academic College of Engineering (Messinger *et al.*, 2009). Face-to-face and group interaction between students and educators around the world (including in developing countries), access to resources and knowledge, voice communication, examination of abstract and complex models through 3D visualisation or projections of visual information are factors that encourage the adoption of virtual worlds in universities and other education institutions (see Danforth *et al.*, 2009;). The Harvard Extension School, for instance, is using *Second Life* to facilitate distance learning (see Figure 7). Furthermore, libraries also see great potential to link information and knowledge within virtual worlds without geographic boundaries and to attract the current generation of young people to use library services more readily.

Figure 6. Harvard law virtual distance education classroom



Note: See also Second Life's educational platform at secondlife.com/education.

Source: OECD

Virtual worlds can thus make learning easier, safer and more cost efficient than via textbooks and science labs. According to a survey conducted by the Duke University School of Nursing, for example, students have indicated a higher level of satisfaction when learning through virtual worlds compared to other online learning systems (Johnson *et al.*, 2009). Especially for children in middle schools studying science where expensive apparatus and lethal substances are not available or not desired for experiments, virtual worlds such as *whyville.net* are an inexpensive and exciting alternative (Wilson, 2008). 3D learning environments such as the *Alice project*[25] can be expected to encourage further the use of virtual worlds for education.[26]

Training

Virtual worlds also provide interactive environments for training. The benefit of using virtual worlds for training mainly comes from its ability to provide realistic and interactive role-playing simulations for training situations. For instance, *Forterra Systems* which was originally developed by *There.com*, provides tools for building private training environments based on its *Online Interactive Virtual Environment* (OLIVE) platform. Clients include for example the U.S. National Institute of Health for emergency-disaster research and training. The following sections will present in more detail how virtual worlds are being used for *i)* medical training; as well as for *ii)* security and defence training.

Medical training

Virtual worlds such as *Second Life* can provide immersive learning environments for medical training. Typical uses include emergency and disaster simulation training (see Kamel Boulos *et al.*, 2008), or realistic and interactive role-playing simulations for training *e.g.* doctor-patient interaction and communication, and clinical diagnosis skills (see Skiba, 2009; Danforth *et al.*, 2009).

In traditional medical training, students are often supposed to train with *simulated or "standardised" patients*, as a means to develop skills in clinical reasoning, physical examinations, history-taking, patient diagnosis, and doctor-patient relationship (Brender, 2005). Standardised patients are real persons and "members of the local community, trained to enact a particular illness or condition" (Danforth *et al.*, 2009). However, training through standardised patients is often not available to all students due to their limited number and their relative high costs.

Virtual patients (*i.e.* computer-controlled avatars in virtual worlds) have been proposed as complement tools for medical training. In contrast to standardised patients, virtual patients can be duplicated and modified without significant costs, making them available for every medical student. Although virtual patients can only simulate real patients to a very limited extent, they can be successfully used to train basic doctor-patient interactions and clinical diagnosis skills as well as be used for medical areas, where using standardized patients is not possible such as, for instance, in basic surgical training. Overall, virtual worlds for medical simulations enable students "to rehearse professional behaviors in a risk-free environment, providing opportunities for skills practice prior to real-world patient encounters" (Danforth *et al.*, 2009).

Security and defence training

Virtual worlds are also being used for security and defence training by military and defence organisations, which are estimated to own the majority of government's space in virtual worlds. For example, according to Michael Piller, director of Academic Computing and Laboratories at the National Defense University's iCollege, 60% of virtual land owned by the United States government belongs to the Defense Department (Long, 2010).

Virtual lands such as the *Military Lands* (MiLands) in *Second Life*, are being applied for collaboration between the different armed forces; including for training but also for outreaching residents, as well as for family counselling, simulation, and prototype testing.[27] The usage of virtual worlds is not limited to public virtual worlds only. Many virtual worlds used in security and defence training are private such as *Virtual Battlespace 2* (VBS2), for instance, which is being used by military and defence organisations such as the United States Marine Corps, the Australian Defence Force and United Kingdom's Ministry of Defence for "mission rehearsal, tactical training and simulated combined arms exercises" (Bohemia Interactive, 2008). It is based on the game middleware *Real Virtuality 2*, which has also been used for creating well known video games such as *Operation Flashpoint* (Xbox) and *ArmA* (PC) (see section below on the driving role of game middleware). Another virtual world used for security training and defence is Quantum3D's *Dismounted Infantry Virtual Environment*.

Limitations and challenges

One of the biggest challenges in adopting virtual worlds for education and training is the difficulty integrating them in traditional formal educational settings. As Sefton-Green (2005) has pointed out in regard to the use of ICTs for education, "computers and other aspects of […] ICTs […] allow children and young people a wide variety of activities and experiences that can support learning, yet many of these transactions do not take place in traditional educational settings. In fact many of these may not be considered 'educational' according to our conventional understanding of that term". This is particularly true for virtual worlds, which are still mainly perceived as online gaming platforms, and where the benefits are still hard to quantify.

Another limitation and challenge for the adoption of virtual worlds is the lack of educators with skills and knowledge in how to use virtual worlds for educational purposes. This may also be linked to the still limited understanding of the impact of virtual worlds on education, suggesting an overall need for more qualitative and quantitative research in this specific area.[28]

Tele-working and tele-conferences

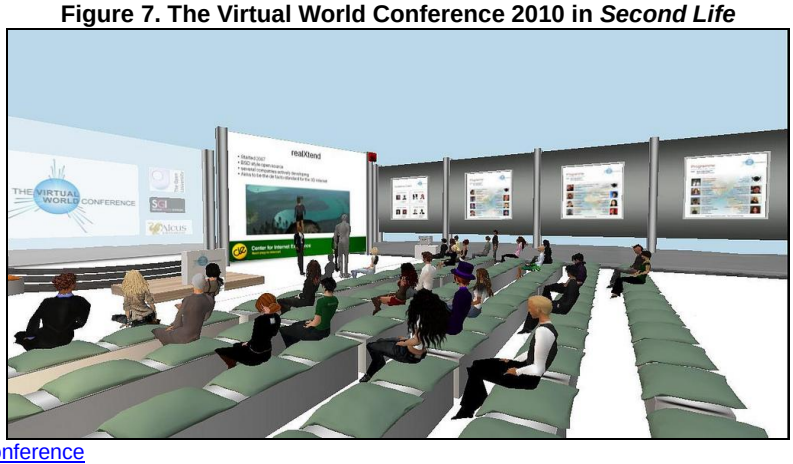
Virtual worlds provide opportunities to improve environmental performances through virtualisation and dematerialisation of resource demanding processes in households, businesses, and governments; and

thus are potential platforms for promoting green growth.[29] These enabling effects (*i.e.* second order effects) include the substitution of travelling and commuting through tele-working and tele-conferences.

Tele-working and tele-conferences are ICT applications which have been discussed as potential replacements of travel and commuting since the 1960s. However, the uptake of these applications has remained relatively modest when compared to their potential to reduce (*e.g.* travelling and commercial real estate) costs as well as environmental impacts. In the European Union, for example, only 13% of employees were estimated to have teleworked in 2002 and 23% of enterprises in the EU15 employed teleworkers in 2006 (see OECD, 2010f; see also OECD, 2010h).

One of the main obstacles reported to be slowing the uptake of tele-working and tele-conferences has been the face-to-face interaction still required for most daily interactions (see Cagle, 2008). Virtual worlds provide a unique environment where people can meet online, while still experiencing a sensation of "being there" (see previous sections). Technology enablers provided by virtual worlds such as shared voice, shared visuals (of avatars), shared computer aided design systems, shared repositories of digital files and folders have all made the use of virtual worlds to support collaborative work activities possible. Conferences and meetings completely hosted in virtual worlds such as *The Virtual World Conference*[30] in *Second Life* are prominent examples on how virtual worlds are increasingly attracting online workers while at the same time reducing their environmental impacts and saving *e.g.* travelling costs (see Figure 7).

Figure 7. The Virtual World Conference 2010 in *Second Life*



Source: Virtual World Conference

Limitations and challenges

Despite the environmental opportunities that the adoption of virtual worlds brings, virtual worlds have not been adopted in main stream tele-working and tele-conference application by the market yet. The lack of skills in using virtual worlds but also the significant costs associated to their deployment may still slow the use of virtual world. Virtual worlds do not exist in a vacuum, but are based on real-life ICT infrastructure including data centres, networks, and end-user terminals such as PCs or mobile phones. Thus, there are costs (including environmental costs) associated with the increasing adoption of virtual worlds. Overall environmental costs includes (direct) environmental impacts (*i.e.* first order effects) such as the increasing energy consumption by data centres hosting virtual worlds as well as end-user terminals through which the avatars are being controlled (see Box 2). Estimations by Carr (2006), for example, suggest that *Second Life* (including the servers on which it runs, the required cooling of these servers and end-user PCs) consumes per day in total 60 000 kilowatt-hours (kWh) or 4.8 kWh per avatar (see also Arthur, 2006). Under the assumption that the avatar is not only active 24 hours a day but also 365 day a year, an average avatar would consume 1 752 kWh a year, an amount higher than the average energy consumption of Turkmenistan in 2005 (1 731 kWh). Although these estimations are based on exaggerated assumptions, it shows that energy consumption of virtual worlds can be significant.

Box 2. How green is the Internet?

The balance of direct, enabling and systemic impacts determines how green the Internet is. There has been discussion about the carbon footprint of various Internet activities, e.g. using a search engine to look for information. Apart from narrowly-focused accounts of the electricity use and related CO2 emissions of individual companies, more systematic studies have estimated the electricity footprint of servers and data centres to be around 1% of global electricity consumption (153 TWh in 2005) (Koomey, 2008). Operators of servers and data centres doubled their electricity consumption between 2000 and 2005; the trend is expected to continue into 2010 (Fichter, 2008). Global data for electricity use by communications networks and equipment are not available, but in the European Union they are estimated to consume around 1.4% of total electricity used (or 39 TWh) (Bio Intelligence Service, 2008).

Organisations that want to reduce electricity use by data centres can do so in various ways, e.g. by allowing higher temperatures in data centres or by virtualising and consolidating servers (Fichter, 2008). Further reductions in electricity use, related costs and emissions are possible through cloud computing. Cloud computing helps rationalize servers and networks by consolidating computing and storage on a system-wide level, e.g. across the federal government. The United States General Accountability Office (GAO), for example, has launched a central cloud computing service, Apps.gov, which helps government agencies to reduce the need for dedicated data centres. Cost savings across the US government are estimated to be as high as 50% with the bulk coming from lower electricity bills (Brookings Institution, 2010).

In order to calculate net environmental impacts, both enabling and systemic impacts of the Internet and cloud computing must be accounted for. Using the framework presented in this report, studies need to account for the environmental benefits of Internet-based applications, e.g. telework that replaces physical commuting or digital music that replaces consumption of physical media products (enabling impacts). The Internet also brings about changes in lifestyles and acts as a source of information and knowledge. Information can be used to orient individuals towards more sustainable behaviour or to inform policy decisions, e.g. about mitigation and adaptation to climate change (systemic impacts).

Source: OECD (2010f)

Research and development

Virtual worlds are also being used as platforms for new ways of doing collaborative research and development (R&D). As is the case for education and training, the main benefits of using virtual worlds come from richer and more dynamic social interactions and collaboration over the Internet compared to other ICT-based collaboration environments (including web 1.0 and 2.0 platforms such as websites, wikis, blogs and even social networking sites). This enables real-time group interaction between researchers, businesses and end-users. The 3D visualisation and design as well as projections of visual information which are inherent in virtual worlds also support R&D. Thus, virtual worlds provide Internet based platforms for *open innovation*, understood as "a customer-centric innovation process, where value is co-created together with selected customers, [and] where the customer is involved as a source for ideas, technical solutions, design or even first prototypes" (Kohler *et al.*, 2010; see also OECD, 2008a and 2010a). In the following, the use of virtual worlds for *i)* collaborative research and *ii)* product development is presented in more detail.

Collaborative research

Virtual worlds are being used as additional and complementary tools for research. Their ability to enhance multidisciplinary collaborations, and especially remote collaboration, data and resource sharing, data integration, information management and knowledge handling make them a promising solution for *e-science*, that is the application of ICTs to expand scientific research capacities and activities. For example, virtual worlds can be used to build *virtual laboratories* (in the broad sense), that are "electronic workspace[s] for distance collaboration and experimentation in research or other creative activity, to

generate and deliver results using distributed information and communication technologies" (Wu, 2009).[31] Fundamental principles of virtual laboratories such as data collaboration, resource sharing and independence from time and space are therefore also valid in virtual worlds.

The analysis of scientific publications reveals that sociological and economic research still remains the main field of research in virtual worlds.[32] For example, interviews and ethnographic research are done in *Second Life*, with researchers constructing facilities comparable to real-world laboratories and recruiting research subjects, for instance to mount formal experiments in social psychology or cognitive science. MMOGs such as *World of Warcraft* are also being used for nonintrusive statistical methodologies examining social networks and economic systems, since they naturally generate diverse data about social and economic interactions. Researchers in the social and economic sciences have increasingly looked to the Internet as a means to expand the scope of their research, and virtual worlds may be a new opportunity to realise this expansion (see Castronova and Matthew, 2008; Yee, 2008).

Researchers such as Wagonner (2009) have examined how humans conceptualise and perceive their own avatars during social interaction. Fiedler and Haruvy (2009) have discussed the evolution of co-operation between individuals through experiments conducted within *Second Life*. The University of California, Los Angeles, as another example, has used the children's virtual world *Whyville* in an experimental study of reactions to a measles-like epidemic affecting the avatars. Scientists such as Castronova (2005) and Chesney *et al.* (2009) have used virtual worlds as platforms for economic experiments. Many of these works have not detected significant overall differences between behaviour in virtual experiments and those observed in traditional settings. This suggests that social and economic behaviour in virtual worlds might be based on similar behavioural regularities observed in standard economic settings and in the virtual environment. Thus well-designed social experiments in virtual worlds can be reliable sources of information (see Williams, 2010).

Overall, virtual worlds enable *i)* experiments to be scaled up from the usual small number of subjects to in principle an endless number of subjects.[33] Furthermore, *ii)* they allow the crossing of socio-cultural boundaries, including research subjects from previously under-represented groups. Virtual worlds also enable *iii)* the study of processes that take place over longer periods of time, including weeks or even months. Last but not least, virtual worlds can *iv)* bring researchers together using several technology enablers such as shared voice (similar to telephone), shared visuals of avatars (similar to video conferencing), shared active databases, shared computer aided design systems, shared repositories of digital files (similar to wikis), and shared folders on an intranet. These enablers make the use of virtual worlds to support collaborative research activities possible. Since 1997, with the creation of *NetLab* by the National Science Foundation, these different opportunities of virtual worlds have been discussed.

Collaborative development

Virtual worlds have also been used as online platforms for collaborative product development and testing. Firms such as Osram (Germany-based light manufacturer), Starwood Hotels & Resorts Worldwide (United States-based hotel chain owner), and Toyota (Japan-based car manufacturer), have used virtual worlds to involve users in the development of new goods and services along the entire innovation process; including: *i)* the identification of new trends or unsatisfied needs; *ii)* the generation of new ideas and technical solutions; *iii)* the design, testing and prototyping of new goods and services; and *iv)* the launch or improvements of these products (see Kohler *et al.*, 2010). Osram, for example, started an idea contest in *Second Life*, inviting users to contribute ideas for new lighting concepts. Starwood Hotels & Resorts first tested its new range of hotel designs within *Second Life*, which led to several design changes before constructing these hotels in real life. These changes have been based on observations of the behaviour of avatars visiting the virtual hotel as well as the feedback they have provided (see Kohler *et al.* 2009; Messinger *et al.*, 2009). Car manufacturer Toyota also used *Second Life*, but to prototype the *Toyota Scion*,

during which avatars could discuss, evaluate, modify, and further develop the model. Firms are also increasingly implementing private virtual worlds for corporate collaboration using server platforms such as *OpenSimulator* or Rivers Run Red's *Immersive Workspaces*, a platform integrating the web and virtual worlds.

An analysis of use cases and examples of product development in virtual worlds highlights two main factors for supporting the adoption of virtual worlds for product development: *i)* a closer and richer interaction between firms and end-users (avatars); and *ii)* the empowerment of end-users to create together with others (UCC). The closer and richer interaction results in the ability of virtual worlds to enable a *media-richer* interaction between avatars and their environments compared to other web (1.0 and 2.0)-based platforms such as websites, wikis, blogs and social networking sites (see Steuer, 1992; Ijsselsteijn *et al.*, 2000). In a virtual world, avatars can not only share text, video and audio files, but also voice and visual expressions, and the time-space experience created in the case of 3D environments provides the sensation of "being there" with others (see Schroeder, 1996 and 2008; Ijsselsteijn *et al.*, 2000). "This leads to a closer and richer interaction between consumers and actors inside the company" (Kohler *et al.* 2010). Thanks to built-in tools provided by some operators of virtual worlds, end-users can also develop virtual goods alone or together with others. This freedom, which is more developed in SVWs, empowers end-users to participate actively in the (co-) creation of new virtual products (including goods and services). These new products can then be commercialised through virtual businesses (see previous section), or even recreated as real-life goods and services (see for example a case in which a bed produced by the company EROS in *Second Life* has been imitated in real life by a third party).

Limitations and challenges

Despite the advantages and applications outlined above, there are also a number of concerns about the adoption of virtual worlds for research and development, beside the costs already mentioned above. Demographic or cultural idiosyncrasies of virtual subjects have frequently been cited to be a major limitation here (see Kohler *et al.*, 2010). For experimental research, this may generate a sample bias making the sample not representative of the population at large and thus renders virtual experimentation inappropriate to test general social or economic theories. In addition, some population groups are currently not sufficiently represented in virtual worlds, including individuals from smaller and traditional societies. There are also differences in socio-economic characteristics between, for example, those populating created environments such as *Second Life* and university populations with more qualifications on average than the general population, and which are often the subjects of social and economic experiments. There is some evidence, however, that subject values in virtual worlds are closer to the general populations of economic agents.

Another important factor challenging the use of virtual worlds for R&D is the lack of interest in research or development by virtual world users, sometimes leading to virtual laboratories and virtual corporate presences becoming "ghost towns" (Kohler *et al.*, 2010; see also Rose, 2007). As Kohler *et al.* (2010) have pointed out, however, in most cases this is due the "lack of knowledge on how to attract innovative avatars". Virtual lab researcher and corporate developers wishing to engage avatars have to provide "a compelling experience for users of virtual worlds", say the authors. This includes most of all an entertaining interaction between users on one side and researchers and developers on the other side.

Furthermore, collaborative development requires users to be able to use the provided tools to build virtual items. At the current state, this requires users to be technology-advanced in their knowledge and orientation. According to Michael Dowdle of *Kaneva*, a competing virtual world of *Second Life*, "*Second Life* is for the more tech-savvy early adopters. It is a complex, open platform to be creative and for building 3D spaces and items. However for the masses, it can be difficult to use with its steep learning curve for creating virtual items" (Messinger *et al.*, 2009).

E-government and public sector information

Virtual worlds also provide opportunities for the public sector to reach the new Internet generation. The two main areas in which virtual worlds have been used by the public sector in addition to security and defence are: *i)* for increasing citizen participation among Internet users; and *ii)* for providing public sector information (PSI) in a media-rich and interactive way.

Increasing citizen participation

For example, the European Service Network (ESN), a Belgium-based communications agency, is developing a virtual European Parliament, in which users will be able to discuss European law and participate in the issues debated in the EU Parliament (Summer, 2010). The goal of the platform is "to generate interest and raise awareness about the role of the European Parliament", according to the description of the tender released by the European Parliament's Directorate-General for Communication. Other examples of how virtual world users are engaged in political debates include a wide range of election campaigns such as the United States' and France's presidential elections in *Second Life* (see Moore, 2007).[34] Another example includes the *Second Health* project where a virtual environment was used for policy consultation that integrated a lot of elements from in-world workshops, a virtual version of potential health care provision and videos shots in Second Life, which were then published on YouTube.[35]

Enhancing public sector information

Virtual worlds are also being used to enhance public sector information, by making it media-rich, more interactive and better available. This includes geospatial data as well as digitised content of museums, galleries, science centres and other public institutions. For example, SEGITTUR (the Spanish Society for the Management of Innovation and Technology in Tourism) and Geovirtual (a company specialised in 3D graphics) are developing a 3D virtual guided tour of Spain, which also include "virtual worlds making it possible for visitors to make informed decisions about Spanish holiday destinations and activities" (EPSI, 2009). The virtual world will be linked to other media including high resolution images from the Spanish National Geographic Institute, and high resolution aerial images and videos of geographic attractions.

Museums, galleries, science centres and other public institutions are also using virtual worlds to make their content available to the wider public, thereby allowing users to experience a tour of the virtual representation of the real-life collections.[36] As Hawkey (2004) has highlighted, "virtual visitors to museum websites already out-number physical (on-site) visitors, and many of these are engaged in dedicated learning activities". Examples of public institutions being represented in virtual worlds include the *Old Masters Picture Gallery* in Dresden, Germany (see Figure 8), the Exploratorium, museum of science, art and human perception in San Francisco, the United States, and the United States National Aeronautics and Space Administration (NASA).[37]

Figure 8. The Old Masters Picture Gallery in Dresden, Germany (left) and in *Second Life* (right)

Source: www.wired.com

Limitations and challenges

So far the public sector has been relatively cautious in adopting virtual worlds. As has been previously stated, the largest public sector activities in virtual worlds are directed to security and defence training. The demographic structure of virtual world users with the younger population still the dominant user group of virtual worlds may have made virtual worlds, less of a priority for governments.

Drivers of virtual worlds

The development of virtual worlds depends to a large extent on game technologies such as 3D graphics and real-time interactivity, but also on the spread of broadband. Therefore, R&D and technology developments in the computer game industry as well as broadband deployment initiatives remain of key importance for virtual worlds. Furthermore, given the game-like nature of virtual worlds, demographic factors which influence the adoption of computer games tend to be significant for virtual worlds as well. These are dealt with in turn below.

Computer game and Internet technologies

Hardware performance

Better processor performance increases the quality of the virtual world experience and drives advances in design and technology. Also, every new generation of 3D software drives the demand for high-end processors and computer power. Thus demand for high-performance ICT infrastructure is kept high. This includes for example the speed of high-end CPUs, which continues to increase especially thanks to the continuing development of multi-core chips. Furthermore, high-performance consumer computers enable those with the necessary skills to contribute to the creation and extension of virtual worlds.

Investment in software and game R&D

Investments in software-related development and in particular game software are important for the development of virtual worlds, which to a large extent build on the same advanced infrastructure, hardware and software as (online) computer games (see Box 3 for an example discussing middleware). ICT industries generally invest heavily in R&D to create increasingly complex and efficient goods and services (OECD 2010b), and countries with a high concentration of ICT R&D, particularly in software, may be at an advantage in providing the conditions for computer games development and thus for virtual worlds. However, there is not an automatic spillover from the relative national focus of R&D on ICT to the development of virtual world technologies. The most important developer countries of game technologies (the United States, Japan and the United Kingdom) are not necessarily those which are most specialised in ICT R&D (see OECD, 2010b).

Large software firms, in particular, invest significantly in R&D. In 2009 they were among the leaders in terms of R&D intensity, spending the equivalent of more than 25% of total sales on R&D (OECD, 2010b). Electronic Arts (publisher of virtual worlds *The Sims Online* and *Warhammer Online*) is the largest ICT R&D spender in the ICT sector in terms of R&D intensity (35% of sales are dedicated to R&D in 2009). Other innovative firms such as NVIDIA and Advanced Micro Devices (3D graphics) or Intel and Nokia (mobile 3D graphics) are contributing to the industry's dynamism, bringing new developers, improved technology, and new types of game technologies spilling over to virtual worlds (see Table 3).

Box 3. Middleware: The engine of virtual worlds

Middleware (including game engines) is software designed for game and virtual world development, and includes components such as 2D and 3D rendering engines, physics engines, Artificial Intelligence (AI) engines and networking platforms. Middleware suppliers have usually been game development studios with highly skilled staff (mathematicians, programmers), who have developed the middleware and content of the game separately, so they can license the middleware to other software developers. Epic Games' *Unreal Engine*, for instance, was first implemented for the first-person shooter game *Unreal*, and then licensed out for dozens of games and virtual worlds such as NCsoft's *Lineage II*. However, as the middleware market expands a number of large established firms have entered including Microsoft and Electronic Arts, along with new companies specialized in single middleware components such as Interactive Data Visualization with their product *SpeedTree*, a 3D rendering engine designed to provide representations of trees and foliage.

Technological advances have increased the realism but also the complexity of virtual reality-based environments, and, as a result, their development time and costs. Generally applicable, interchangeable, interoperable middleware is seen as a solution to contain rising costs, allowing developers to focus mainly on the creative side of the development process and licence middleware technology. Licensing middleware thus may provide smaller developers with the technology to better compete with large ones. According to the Acacia Research Group, third-party solutions account for 25% of total spending on game engines, and it is expected to increase from USD 79 million in 2006 to more than USD 108.4 million in 2011. This may partly be due to the developers' wish to work on the underlying software either to accommodate it better to their game or to update it. If licensed technology is used, contracts will often stipulate that improvements made by third parties will not confer property rights over the improvement to them. Here, open source middleware like *Panda3D* (3D engine) or *Project Darkstar* (network platform) can be an alternative to commercial solutions as they enable the free distribution of technical improvements and innovation, and foster the development of open virtual worlds such as *OpenSimulator* and *RealXtend*.

Table 3. Top ICT R&D spenders: R&D intensity (R&D expenditure as share of sales), 2000 and 2009

Percentages

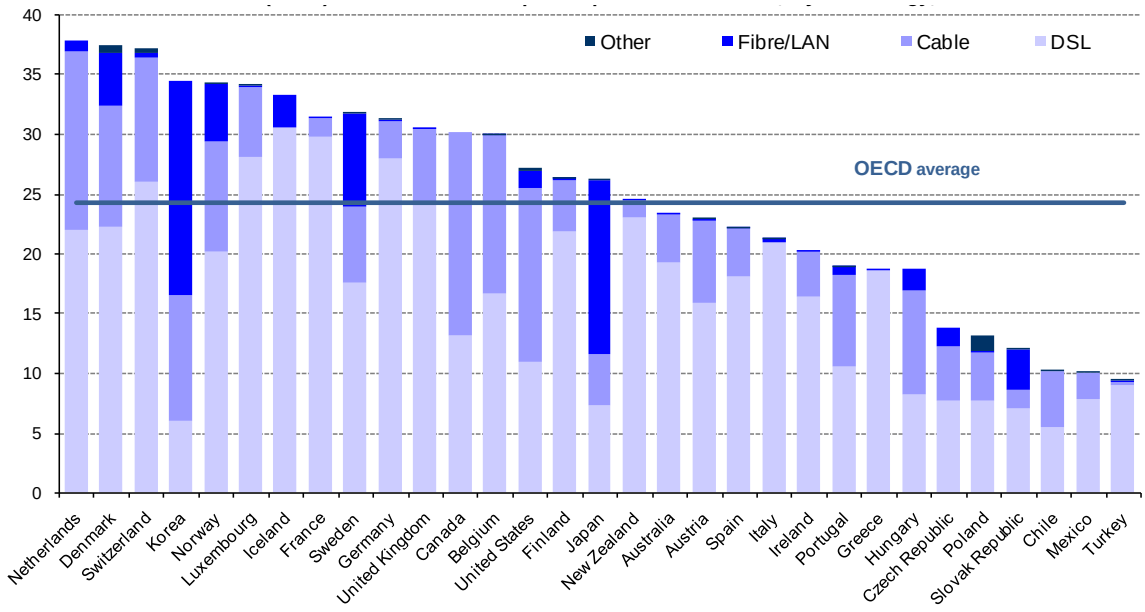
Rank	Company	Country	Industry	2000	2009
1	Electronic Arts	United States	Software	28%	35%
2	Broadcom	United States	Semiconductors	31%	34%
3	Advanced Micro Devices	United States	Semiconductors	14%	32%
4	Marvell Technology Group	Bermuda	Semiconductors	24%	29%
5	ASML Holding	Netherlands	Semiconductors	11%	29%
6	NVIDIA	United States	Semiconductors	12%	27%
7	STMicroelectronics	Switzerland	Semiconductors	13%	25%
8	Qualcomm	United States	Communications equipment	11%	23%
9	Juniper Networks	United States	Communications equipment	14%	22%
10	NXP Semiconductors	Netherlands	Semiconductors	..	22%
11	Freescale Semiconductor	United States	Semiconductors	17%	22%
12	Adobe Systems	United States	Software	19%	19%
13	Yahoo!	United States	Internet	11%	19%
14	Applied Materials	United States	Electronics & components	12%	19%
15	Nortel Networks	Canada	Communications equipment	13%	19%
16	Intuit	United States	Software	16%	18%
17	Tokyo Electron	Japan	Electronics & components	5%	18%
18	Alcatel Lucent	France	Communications equipment	9%	17%
19	Intel	United States	Semiconductors	12%	16%
20	Ericsson	Sweden	Communications equipment	15%	16%

Source: OECD, Information Technology Database, compiled from annual reports, SEC filings and market financials.

Broadband

Broadband is diffusing rapidly and is a significant driver of the adoption of virtual worlds. Between 2003 and 2010, broadband penetration (subscribers per 100 inhabitants) has more than doubled in OECD countries and is especially high in those countries with a significant market for virtual worlds (30 subscribers per 100 inhabitants or more in Northern Europe and Korea) (Figure 9). The average advertised download speed has also increased in OECD countries and is very high in the biggest markets for virtual worlds (Japan: 107 725 Mbit/s, Portugal: 103 718 Mbit/s, France: 54 551 Mbit/s, and Korea: 52 772 Mbit/s).[38] In Korea and China the spread of Internet cafés has contributed significantly to the uptake of virtual worlds and MMOGs in particular.

Figure 9. OECD fixed broadband subscribers per 100 inhabitants, by technology, June 2010



Source: OECD Broadband Portal, *www.oecd.org/sti/ict/broadband*

Overall, the potential for virtual worlds is growing rapidly everywhere, but broadband penetration has important effects on building a critical mass of users, in particular for more advanced "serious" applications. Countries with high broadband penetration rates are thus more likely to develop a mass-market for virtual worlds. The Korean experience, which can also be observed in other South-Asian countries (*e.g.* China), confirms the idea that the growth of broadband and the growth of virtual worlds go hand-in-hand, although this observation is mainly based on the development of MMOGs (also see *PwC*, 2007).

Demographic factors

Given the game-like nature of virtual worlds, demographic trends observed in the context of online computer games can be expected to drive the adoption of virtual worlds for "serious" applications. This is because the game experience of users is most likely to increase their ability and desire to use virtual worlds in non-pure entertainment areas. The two main demographic trends that have been identified in OECD research (OECD 2006) in the context of online computer games include: *(i)* "players […] getting older and

richer", and *(ii)* "more women […] using computer games". Both trends are being discussed below in the context of virtual worlds.

Age

According to surveys, online computer games are increasingly attractive to all ages but virtual worlds still remain a platform mainly for the younger population. According to Yee (2005a), the average age of MMORPG players is around 26 with 25% of MMORPG players being teenagers.[39]

Statistics by the Pew Internet & America Life Project (2008b) on video game users in the United States reveals that 53% of the population aged 18 and older play video games, and adults tend to play video games more frequently the older they get. 36% of the population aged 65 and older is playing every day or almost every day, compared with 19% of adults aged 50-64, 20% of adults aged 30-49, and 20% of adults aged 18-29 (compare Nielson Games, 2008 for similar demographic trends in Europe). However, the dominance of younger players is more evident in virtual worlds and adults tend to visit fewer virtual worlds the older they get. Only 9% of adults in the United States have played MMOGs, compared to 21% of all teens. Only 2% of adults have visited a VSW, such as *Second Life*, compared to 10% of all teens (Pew Internet & America Life Project, 2008b).

In Korea, the aging of the playing population can also be observed: The share of players aged 45-49 has increased from 37% in 2004 to 48% in 2006. In contrast to the trend observed in the United States, playing online games does not significantly depend on age in Korea. According to the Ministry of Culture and Tourism and the Korean Game Industry Agency (2006), children aged 9-14 and 15-19 are the most likely age groups to play online games (83% and 81%), but are followed by adults aged 45-49 (79%), adults aged 20-24 (78%), and adults aged 40-44 (76%).

Surveys have however shown that teens (11-17 years old) are more likely to become heavy users of virtual worlds (see Figure 4). According to Yee (2005b) based on 1 966 virtual world users (1 587 men and 379 women), users spend on average 21 hours per week in virtual worlds. The hours spent is significantly higher for teens, who spend on average 25 hours per week in virtual worlds.[40] This is consistent with observations made in *e.g.* Korea, where more than 17% of the gamers aged 15-19, 16% of the gamers aged 20-24, and 14% of the gamers aged 45-49 play more than 5 hours on average per game session.

Gender

Surveys have confirmed the dominance of men in the world of video games. However, an increasing number of women are playing video games, and in particular using virtual worlds. In some countries the likelihood of a man playing video games is only slightly higher than for a woman. In the United States, for instance, 55% of adult men vs. 50% of adult women are playing video games. In Korea, the difference is higher: 86% of men have game experience compared to 63% of women (see Ministry of Culture and Tourism and the Korean Game Industry Agency, 2007), and in countries like Finland and Spain, men are twice as likely to be active gamers compared to women.

However, there is some evidence that virtual worlds and especially MMORPGs increasingly attract women. In Korea, for instance, the share of women playing online games including MMOGs (83%) is even greater than that of men (73%) (Ministry of Culture and Tourism and the Korean Game Industry Agency, 2007). However, this is not the case in the United States and in Europe, where men still dominate the world of online games and MMOGs (Nielson Games, 2008; Nichols, 2008).

Men are also more likely to become heavy users of virtual worlds.[41] While this is particularly true for the younger population, the opposite is true in the case of adults older than 35. According to Yee (2005b), 11-17 year old boys spend 25 hours a week and girls of the same ages spend 24 hours a week. In contrast,

men older than 35 spend 19 hours a week in virtual words compared to 25 hours a week spent by women in virtual worlds (see Figure 4).

Policy opportunities and challenges

There are policy opportunities and challenges, which, although they apply outside virtual worlds, have intensified due to the growth of these platforms. Rising policy opportunities and challenges are expected in: *i)* fostering R&D, innovation and creativity; *ii)* enhancing infrastructure, as well as in regulatory environment issues such as *iii)* excessive use and addiction; *iv)* mature, inappropriate, and illegal content; *v)* taxation; and *vi)* classification and measurement.[42] These policy issues are dealt with in turn below.

Promoting R&D, innovation and creativity

R&D, innovation and technological spillovers

As was discussed in the previous section, the creation and successful deployment of virtual worlds relies heavily on R&D in Internet and game technologies, such as faster networks, new game engines and middleware, and improved Graphics Processing Units (GPUs). These technologies are increasingly R&D-intensive and often their development involves high risks. To give a benchmark, the development of a video game is often a two-to-three year process, which can reach average costs of USD 10 to USD 50 million, with as much as 30-40% attributable to R&D and innovation (BBC, 2005; OECD, 2007).[43]

Governments have an on-going role in encouraging R&D and innovation, and all OECD governments provide incentives to R&D (*e.g.* current year write-offs, and R&D tax credits) that could in principle also apply to R&D for Internet and game technologies. Yet in many cases it is still unclear to what extent the development of games and in particular game-like applications such as virtual worlds can benefit from general R&D incentives, despite their economic and social benefits in non-pure entertainment areas as highlighted in this report.

Furthermore, the uncertain classification of virtual worlds – whether they are regarded as computer games or as Internet content platforms – makes the application of R&D tax schemes even more complicated (for the classification issue see section below). This has significant implications, for example, for policies targeting the game industry explicitly. Government support, which is offered to promote the creation of cultural products through *e.g.* direct tax breaks, has grown in importance in countries such as Australia, Canada, France, Korea, New Zealand and to some extent in the United States. Some government measures include:

- The *Gateway Fund* of Canadian Culture Online providing up to CAD 50 000 "for any single project with 25% of the project budget contributed by the applicant" (Nordicity, 2008).

- The creation of the Korean Games Industry Agency (KOGIA) by the Korean Ministry of Culture and Tourism (in 1999), with the goal of "developing the game industry as a key future strategic industry of the country" (KOGIA, 2006).

- The *Nordic Game Program* created and funded by the Nordic Ministers for Culture, representing Denmark, Finland, Iceland, Norway and Sweden, which has invested up to DKK 10 million in 2009 to "ensure access to quality material with a distinct Nordic element in computer games for children and young people" (Norden, 2006).

These measures are directly effecting the development of virtual worlds; but only when these virtual worlds are considered as computer games worthy of support. Most importantly, governments explicitly

supporting the game industry should also encourage technological and other spillovers and diffusion in areas that are becoming increasingly relevant in non-pure entertainment areas, such as, for example, virtual reality and data visualisation technology for educational, medical and other fields.

Skills, education and training

The complexity associated with the development of virtual worlds and the new user interfaces required demand additional and partly new ICT-related skills and knowledge for developers and designers, but also for the end-users. Where virtual worlds are mainly built by users, the skill requirements for end-users can be significant and could hinder the development and adoption of the virtual world.

Demand for highly specialised skills by developers (studios) of virtual worlds has intensified as the complexity of these worlds grows alongside user expectations. The ICT sector has traditionally faced considerable mismatches between supply and demand for ICT skills, and companies have had a particularly difficult time finding workers with advanced computer game design skills. Shortfalls in domestic supply (owing to lack of educational courses and little training within the industry), restrictions on immigration of highly skilled personnel or difficulties in international sourcing of development tasks requiring large amounts of interaction among teams of developers still constitute a challenge. It is also notable that the number of female employees in the industry is relatively low (see OECD, 2010b).

Most specialist ICT skills needed for the development of computer games and for virtual worlds in particular are not yet obtained from formal university or tertiary institution degree courses, but rather on the job or through self-learning. There is growing trend, however, for universities to provide game-related ICT courses and study programmes, which will increase the availability of highly-skilled developers and designers of virtual worlds. Universities have also started to provide tertiary programmes or have identified skills and job training as key issues for industry development. Yet more efforts in this regard might be necessary.

Enhancing the infrastructure

Broadband access

Virtual worlds, such as Second Life, tend to rely on high capacity broadband networks. As has been highlighted in previous sections, broadband penetration has important effects on building a critical mass of users in virtual worlds, and countries with high broadband penetration rates are more likely to develop a mass-market for virtual worlds. High capacity downloads as well as uploads, high reliability and low latency across the network are important to ensure an immersive experience in virtual worlds. One key technical challenge for the evolution of virtual worlds is the lack of symmetrical bandwidth to end users. The majority of Internet connections are still Asymmetrical Digital Subscriber Lines (ADSL), with the volume of data flow greater for downloading than for uploading. The deployment of new distribution technologies such as optical fibre (as in Japan and Korea) can help overcome this problem.

However, as Morningstar and Farmer (2008) highlight from their experiences with the virtual world Habitat[44], communications bandwidth is a scarce resource and will always remain scarce, since developers tend to utilize as much bandwidth for their virtual worlds as available: “When communications technology advances to the point w[h]ere we all have multi-gigabaud fiber optic connections into our homes, computational technology will have advanced to match” (Morningstar and Farmer, 2008). Thus the deployment of high capacity broadband networks must go along with adequate incentives for innovative bandwidth optimisation techniques such as *e.g.* data compression technologies.

Interoperability and standards

The lack of interoperability between different virtual worlds can be considered one of the major challenges for the wide adoption of virtual worlds. There are considerable lock-in effects due to missing standards between virtual world operators. Users have, for example, criticised the inability to transfer personal data (*e.g.* an avatar or virtual items) from one virtual world to another. Virtual worlds based on open standards and open source projects, such as *OpenSimulator* and *realXtend* could be a solution to this problem. However, the adoption of open standards or open source projects for virtual worlds remains rare, despite the efforts of standardisation groups such as the IEEE sponsored working group looking at "Serious Games and Virtual Worlds' Standards".[45]

Environmental impacts

Virtual worlds rely on real-life ICT infrastructure including data centres, networks, and end-user terminals such as PCs or mobile phones, which can have a significant impact on the environment. These direct effects (*i.e.* first order effects) include the increasing energy consumption by data centres hosting virtual worlds and by end-user terminals through which the avatars are being controlled. But also other environmental impacts during manufacturing or the end-of-life of this ICT equipment such as toxicity, non-energy resource depletion, and land use are significant (see Box 3; OECD, 2010f).

Despite virtual worlds' potential to improve environmental performance through virtualisation and dematerialisation and to enable Green Growth, the increasing number of users and power consumption associated with them shows that operators should watch their energy consumption as is the case for other ICT- and Internet-based service operators relying heavily on large data centre farms. Policies on ICT and the Environment (see OECD, 2009c) and in particular the *OECD Council Recommendation on Information and Communication Technologies and the Environment* (OECD, 2010e) can thus be expected to have a significant impact on the deployment of virtual worlds and will help improve their net environmental impacts across society.

Fostering the regulatory environment

Excessive use of virtual worlds

Virtual worlds may intensify the risk of online addiction due to their advancing ability to blur the boundaries between real and virtual worlds (see section above). Only a few OECD countries, however, report data on online addiction. In Korea, the official number of teenagers with symptoms of Internet addiction was estimated to be more than 900 000 in 2009 out of a total population of around 50 million, a decrease from 1 million in 2007. "But the number of addicts in their 20s and 30s has been increasing, to 975,000 last year" (Sang-Hun, 2010). In total around 2 million people are estimated to be internet addicted in Korea, almost 9% of Internet users or 4% of the total population. The Korean government has programmes to reduce Internet addiction. Examples include the "i-ACTION 2012", a set of measures for raising awareness, counselling, and training, or the free provision of software limiting access time to the Internet for bloggers and gamers (see Hyun-Kyung, 2010).

As was highlighted in the previous section, intensive or even excessive use is not particular to virtual worlds, but relates broadly to how people decide to manage their media usage habits. Users who engage more actively in virtual worlds may have previously been watching TV in a passive fashion, and they may now be creating and maintaining (real) social relationships with others through virtual worlds. Therefore, government initiatives educating end-users and raising awareness about the risk of excessive use of these media can reduce the risk of online addiction.

Mature, inappropriate, and illegal content

Virtual worlds impose few technical limits on users with respect to their thoughts expressed or their mediated actions. Most virtual world providers therefore make it clear in their terms of service that they do not police content or that they do not assume editorial responsibility for the content created (see OECD, 2007).

In respect to adult-oriented content, many providers have voluntary policies in place to restrict access to minors. A study released by the U.S. Federal Trade Commission (FTC, 2009) found, however, that these measures "may not stop kids […] from finding their way in, either accidentally or otherwise". One sexually explicit site aimed at adults, for example, said it was restricted to those over 18, but the analysis of its traffic indicated that 18% of its users were younger than 18. In order to improve the protection of children in virtual worlds, the FTC recommended several general principles, including:

- Using more effective age-screening mechanisms to prevent children from registering in adult virtual worlds.
- Using or enhancing age-segregation techniques to make sure that people interact only with others in their age group.
- Re-examining language filters to ensure that they detect and eliminate messages that violate rules of behaviour in virtual worlds.
- Providing more guidance to community enforcers in virtual worlds so they are better able to review and rate virtual world content, report potential underage users, and report any users who appear to be violating rules of behaviour.
- Employing specially trained moderators equipped to take swift action against rule violations.

Other OECD countries, such as Germany, the UK and France have legal requirements for age verification which can also apply to virtual worlds. In Germany, for example, providers of adult content are required to use age verification technologies and a pre-approval mechanism by the State (see OECD, 2010c and 2010d). Depending on the type of content, virtual worlds may thus be subject to these kind of legal requirements.

Taxation of transactions in virtual worlds

Virtual worlds are increasingly evolving into virtual economies with complex financial transaction models including micro-payments, subscriptions, and trading in virtual assets. These transactions involve purely in-world trading with virtual currencies or exchange of virtual assets but also virtual goods or even virtual currencies being converted into real money. This is sometimes referred to as 'real money trading' (RMT) or 'gold farming' when it becomes a source of income (see Hecks, 2008; Rowenna, 2009; the Virtual Policy Network, 2011).[46]

As has been shown in the previous section, in-world and out-world transactions can be significant. KZERO, a consulting company focussing on virtual worlds and virtual goods, estimates that the total market for virtual items was worth around USD 5 billion in June 2010 and it expects this value to more than double within the next two years (see the Virtual Policy Network, 2011).[47] Other estimates suggest that USD 3.8 billion alone were being generated in Asia in 2009.

All these activities have increasing implications for real-world money flows, and thus for taxation and regulation. This includes but is not limited to: *i)* commercial activities in or around virtual worlds. As examples have shown, an increasing number of people are spending a large proportion of their daily life in virtual worlds (more than 8 hours a day), collecting virtual assets to then sell them in real-life online markets such as eBay. This allows them to earn their (real-life) monthly incomes, usually more than USD 2 000 (see Sang-Hun, 2010), which when aggregated is a significant amount increasingly of interest to tax authorities. Furthermore, questions have also arisen about to *ii)* what degree virtual worlds become equivalent to banks and thus subject to much more stringent financial regulations.

The general rule is that the more closely connected the virtual world activity is to real life, the more financial regulators and authorities would take an interest in them. To some extent this also links to some issues regarding electronic money (*i.e.* e-cash) (see the Virtual Policy Network, 2011).[48] Tax authorities will depend on the taxpayers actually declaring these sales and income to avoid an electronic version of the "underground" economy. At the present time, these issues may not be significant to tax authorities due to the high thresholds for taxes at present, but in the light of the growing influence of virtual worlds, tax authorities will be progressively faced with associated regulatory questions.

Classification and measurement

Many policy challenges hint at a lack of an adequate classification of virtual worlds as one cause of these challenges. This includes measurement challenges but also challenges in R&D and innovation support or taxation measures. The difficulty in classifying virtual worlds is partly due to: *i)* the fact that virtual worlds can hardly be distinguished from pure entertainment online games from a technical point of view; *ii)* the lack of a widely agreed-on definition; *iii)* the different types of virtual worlds being used; and *iv)* the wide range of application areas virtual worlds are being adopted for.

Since the large majority of virtual worlds are still being used in the entertainment area, virtual worlds tend to be classified as computer games. This is most likely to be true for MMOGs, since they have a pre-defined storyline with a set of pre-defined objectives, and in most cases limited opportunities for creation of UCC. These characteristics make MMOGs more similar to traditional (online) computer games. However, the more UCC becomes possible and the more freedom the virtual world provides to users to define their universe, rules and in-world objectives, the harder it gets to justify its classification as a computer game and the more likely it will be classified as an Internet content platform. Where the main purpose of the virtual world is to provide a platform for the creation of virtual items and other types of UCC, the existence of an Internet content platform should be assumed.

In the Australian context, for example, if virtual worlds are regarded as computer games, they would be within the Australian Publications, Films and Computer Games classification scheme. If they are regarded as Internet content platforms, they could fall under the Broadcasting Services Act 1992. An environment such as *Second Life*, for example, would thus not be classified as a game, whereas *World of Warcraft* clearly would under this distinction; yet both contain significant elements of user interactivity, communication, UCC, as well as game-play, although to different extents. This uncertainty has led to boxed add-ons to virtual worlds being removed from sale in Australia because of the lack of official classification. Confusingly, government officials in response to queries admitted their own lack of knowledge as to whether classifications were required.

International co-operation

The regulatory issues presented in this section will increasingly require international co-operation given that virtual worlds can be accessed from any country over the Internet. Trans-national content rating systems such as the Pan European Game Information (PEGI) in Europe and the Entertainment Software

Rating Board (ESRB) in Canada and the United States are just few promising examples of (self-) regulatory instruments being applied across different countries.

Finally, there are a number of important policy opportunities and challenges to the adoption of virtual worlds that have been raised and addressed in other OECD work relating to the participative web and user-created content (see OECD, 2007) as well as to Internet intermediaries (see OECD, 2010c and 2010d) so they will not be dealt with in this paper. These include: *i)* intellectual property rights (IPR) and user-created content (UCC); *ii)* information and content quality; *iii)* safety online as well as privacy and identity theft; and *v)* language and cultural diversity.

Conclusion

There is evidence of the potential for using virtual worlds for collaboration, creativity, and learning; in the private as well as public sector. Promising application areas discussed in this report include: *i)* entertainment and social networking; *ii)* education and training; *iii)* tele-working and tele-conferences; *iv)* research and development; *v)* e-commerce and e-business; and *vi)* e-government and public sector information. Entertainment and social networking still represent by far the most significant type of application of virtual worlds in terms of number of users and market value. But education and training are increasingly getting more attention.

Rapidly increasing bandwidth will have major impacts on the adoption of virtual worlds. But also game technologies such as game middleware, 3D graphics and real-time interactivity will drive their development. Thus, the game industry continues to be the main source for technological spillovers in non-pure entertainment areas. Furthermore, the adoption of virtual worlds still depends on the age of users, with the younger population and in particular boys still being the most active user group in virtual worlds. However, there is evidence that virtual worlds may increasingly attract girls and women.

There are also a number of barriers and challenges to the adoption of virtual worlds. To some extent these challenges are a continuation of existing government issues related to the information society and digital content policy frameworks in particular. These include, for example, questions related to intellectual property rights (IPR), which have been discussed in previous and ongoing OECD work on digital content (see OECD, 2005, 2007) and Internet intermediaries respectively (see OECD, 2010c, 2010d). This also includes issues on information and content quality (see OECD, 2007, 2010c, 2010d), safety online and privacy (see OECD, 2010g), and identity theft (see OECD, 2007; 2009d). In this regard, virtual worlds do not require specific policy provisions as existing laws applicable to electronic communication networks and the Internet are still valid and applicable for virtual worlds.

On the other hand, some policy challenges have intensified with the diffusion of virtual worlds, and thus may require existing policies to be rethought in this novel context. These include issues such as increasing requirements on broadband networks, lack of interoperability and standards between different virtual worlds, increasing skill requirements for developers and end-users alike, but also some regulatory issues such as the increasing risks of online addiction, the increasing significance of in-world transaction for taxation, and classification and measurement issues.

Virtual worlds may still be at an early stage of their development and adoption, but both the opportunities and policy challenges that come along with them will increasingly require policy makers' attention and global co-operation, not only between OECD countries, but also major non-OECD countries. Striking the right balance between non-intervention and regulation – while avoiding over-regulation – is crucial in particular in this early stage in order to preserve the seeds of innovation inherent in virtual worlds.

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ANNEX 1: VIRTUAL WORLDS

Annex Table 1. List of selected virtual worlds

Name	Average age	Population of registered users (in millions)	Country of origin	Website
Interzone Futebol	22	n.a.	Australia	*www.Interzonefutebol.com/*
Taatu	13.5	n.a.	Belgium	*worldcdn.taatu.com/index.html*
Club Penguin	11.8	19	Canada	*www.clubpenguin.com*
Kidstudio	8.3	n.a.	Canada	*www.Kidstudio.com/*
SceneCaster	24	n.a.	Canada	*www.scenecaster.com*
goSupermodel	13	6	Denmark	*www.gosupermodel.com*
Lego Universe	10	n.a.	Denmark	*universe.lego.com*
Habbo	12.8	100	Finland	*www.habbo.com/*
Muxlim	14	n.a.	Finland	*spaces.muxlim.com/*
3-D Explorer	30	n.a.	France	*www.3dxplorer.com/*
Club Cooee	12	n.a.	Germany	*en.blog.clubcooee.com*
Papermint	16	n.a.	Germany	*www.papermint.com/*
sMeet	19	n.a.	Germany	*us.smeet.com*
Weblin	21.5	1.5	Germany	*www.weblin.com*
PlayStation Home	19	n.a.	Japan	*us.playstation.com/psn/playstation-home/*
Hello Kitty	8.7	n.a.	Japan	*www.hellokittyonline.com/us/index.php?c=&s=*
Utherverse	32	n.a.	Netherlands	*www.utherverse.com/*
Small Worlds	17	n.a.	New Zealand	*www.smallworlds.com/login.php*
Visitoons	13.7	n.a.	Spain	*www.visitoonschat.com/en/index.aspx*
Yogurtistan	20	n.a.	Turkey	*www.yogurtistan.com:8080/jsp/index.jsp*
Chugginton	7	n.a.	United Kingdom	*www.ludorum.com/properties/chuggington.html*
Lolas Land	9	n.a.	United Kingdom	*www.lolasland.com/*
Medikidz	11	n.a.	United Kingdom	*www.medikidz.com/*
Near	29	n.a.	United Kingdom	*nearglobal.com/*
Vizwoz	11	n.a.	United Kingdom	*www.vizwoz.com/*

Name	Average age	Population of registered users (in millions)	Country of origin	Website
WeeWorld	14.3	24	United Kingdom	www.weeworld.com/
Virtual Tweens / Ekoloko	10	n.a.	United States	vtweens.com/
Action Allstars	9.2	n.a.	United States	www.actionallstars.com
Activeworlds	23	1	United States	www.activewolds.com
Amazing Worlds	30	n.a.	United States	www.amazingworlds.com/
Barbie Girls	9.5	15	United States	www.barbiegirls.com/home.html
Buildabearville	8.8	2	United States	www.buildabearville.com
Bunnytown	9	n.a.	United States	playhouse.go.com/v1/marketing/index.html
Cyber Town	26	n.a.	United States	www.cybertown.com/main_nsfranes.html
Digital Dollhouse	10	n.a.	United States	www.digitaldollhouse.com/
Dizzywood	10	n.a.	United States	www.dizzywood.com
DMCWorld	18	n.a.	United States	www.dmcworld.com/home.asp
EGO	19	n.a.	United States	www.egocity.com/
Empire of Sports	18	n.a.	United States	www.empireofsports.com/
Football Superstars	27	n.a.	United States	footballsuperstars.com/
Forterra	30	n.a.	United States	www.forterrainc.com/
Franktown Rocks	10	n.a.	United States	www.franktownrocks.com/
FusionFall	13	n.a.	United States	www.fusionfall.com/
Gaia	17	13	United States	www.gaiaonline.com
GeoSim Philly	31	n.a.	United States	www.geosimphilly.com/
Green	11	n.a.	United States	green.com/
Grockit	11	n.a.	United States	www.grockit.com/login
Handipoints	7.5	1	United States	www.handipoints.com
iheartland	24	n.a.	United States	blog.iheartland.com/
IMVU	20	20	United States	www.imvu.com/
Jumpstar	7.7	20	United States	www.jumpstart.com/
Kaneva	21	n.a.	United States	www.kaneva.com/
Kidscom	9.7	1.5	United States	www.kidscom.com/
Konstruction Zone	8.4	n.a.	United States	www.constructionzone.com/kz/app/home
KooDooZ	12	n.a.	United States	www.koodooz.com
Lively	16	n.a.	United States	www.lively.com/html/landing.html
Meez	17.5	7	United States	www.meez.com

Name	Average age	Population of registered users (in millions)	Country of origin	Website
Metaplace	19	n.a.	United States	https://www.metaplace.com/
Mini-Match	9	n.a.	United States	minimatch.cartoonnetwork.com/
MinyanLand	11	n.a.	United States	www.minyanland.com/
Moshi Monsters	10	1	United States	www.moshimonsters.com/
Multiverse	23	n.a.	United States	www.multiverse.net/index.html
My Mini Life	12	n.a.	United States	www.myminilife.com/
Mycosm	25	n.a.	United States	www.mycosm.com/
Neopets	10	45	United States	www.peopets.com/index.phtml
Nexus	30	n.a.	United States	www.ecsorl.com/solutions/ECS_EMNx.html
Onverse	23	n.a.	United States	www.onverse.com/
Ourworld	15.5	n.a.	United States	ourworld.com/v11/
Pixie Hollow	8	n.a.	United States	pixiehollow.go.com/
Planet Cazmo	11	n.a.	United States	www.planetcazmo.com
Poptropica	9.6	20	United States	www.poptropica.com/
Protosphere	30	n.a.	United States	www.protonmedia.com/
Roblox	11	n.a.	United States	www.roblox.com/
Robot Galaxy	9.2	n.a.	United States	www.robotgalaxy.com
Rocketon	16	n.a.	United States	www.rocketon.com/
Seapals	7	n.a.	United States	www.seapalsworld.com/
Second Life	33	15	United States	www.secondlife.com
Spicy Town	8.5	n.a.	United States	www.spicyside.com/index.aspx
Stardoll	15	21	United States	www.stardoll.com
TechDeck live	19	n.a.	United States	www.techdecklive.com/
There	20.5	2	United States	www.there.com/
Tootsvilles	7	n.a.	United States	www.tootsville.com/index.html
Twinity	36	n.a.	United States	www.twinity.com/en
Ty-Girls	8	n.a.	United States	tygirlz.com/
Vastpark	27	n.a.	United States	www.vastpark.com
Vivaty	20	n.a.	United States	www.vivaty.com/
vLes – Virtual Lower East Side	19.5	n.a.	United States	www.vles.com/
vMTV	20.5	3	United States	content.vmtv.com/mtv central/
vSide	18	0.3	United States	www.vside.com

Name	Average age	Population of registered users (in millions)	Country of origin	Website
Webkinz	9	1	United States	*www.webkinz.com*
Whirled	9.1	n.a.	United States	*www.whirled.com/*
Whyville	9.5	3	United States	*www.whyville.net*
Woogi World	7	n.a.	United States	*www.woogiworld.com/*
Xivio	8.6	n.a.	United States	*www.xivio.com*
ZooKazoo	7	n.a.	United States	*www.zookazoo.com*
Zwinky	17	n.a.	United States	*zwinky.smileycentral.com*
Zwinky Cuties	7	n.a.	United States	*www.zwinkycuties.com*
8D	16	n.a.	China	*www.8dworld.com/english/home.html*
HiPiHi	30	0.1	China	*www.hipihi.com/index_english.html*
Frenzoo	16	n.a.	Hong Kong, China	*www.frenzoo.com/beta/*

Source: OECD based on Spence (2008) and Kzero data.

ANNEX 2: DIGITAL CONTENT PRINCIPLES OF THE OECD POLICY GUIDANCE FOR DIGITAL CONTENT

Digital content principles[1]

The following policy principles will help promote an enabling environment, enhance the infrastructure, and foster a business and regulatory climate conducive to the creation, access to and preservation of digital content.

Promoting an enabling environment

- Policies that encourage a creative environment that stimulates market and non-market digital content creation, dissemination, and preservation of all kinds.
- Policies that facilitate R&D and innovation in digital content creation, dissemination, and preservation, and digital content-related networks, software and hardware, open standards, and interoperability.
- Policies that help ensure that capital markets (*e.g.* venture and risk capital) work competitively in funding innovation and digital content ventures.
- Initiatives aimed at addressing shortages in skills, training, education and human resource development for the creation, distribution and use of innovative digital content.
- Policies that stimulate enhanced knowledge creation, dissemination, lawful use and preservation of different forms of digital content, (including access to information, research, data and publications), encourage investments in such creation, dissemination and preservation, and encourage global access to content regardless of language and origin.
- Policies that enhance access and more effective use of public sector information.
- Creating and ensuring an environment that promotes freedom of expression and access to information and ideas.

Enhancing the infrastructure

- Policies that encourage investment in new network infrastructure, software, content and applications.
- Policies that work to improve regulatory parity and consistent policy treatment across different, and in some cases converging, content delivery platforms (including next-generation networks), technological environments and value chains.
- Policies that encourage technology neutral approaches, interoperability and open standards development to address technological issues related to digital content creation, dissemination, use and preservation.

[1] For consistency the terms “digital content creation, dissemination, and preservation” and “use,” have been used as appropriate in the text unless a particular situation requires the use of a specific term.

- Policies that improve applications for the delivery and use of digital content, including promoting effective management, preservation and dissemination tools that enhance access and use of different types of digital content.
- Policies that promote and enhance accessibility to digital content of all people regardless of location in order to realise the full benefits of the Internet economy and the global digital environment.

Fostering the business and regulatory climate

- Policies that encourage the development of innovative business models, the spread of best practices and the adaptation of value chains in the digital environment.
- Policies supporting non-discriminatory business and policy frameworks that reinforce competition.
- Policies that recognise the rights and interests of creators and users, in areas such as the protection of intellectual property rights, while encouraging innovative e-business models.
- Policies that provide incentives for the creation, dissemination, and preservation of digital content (*e.g.* through open innovation strategies, university-business collaboration, providing incentives for long-term research, and through intellectual property rights).
- Policies to improve information and content quality and accuracy; for example, policies that facilitate the use of tools to help creators identify and disseminate their works and users to identify and access specific information and works.
- Policies that enhance confidence in the creation and use of digital content through effective enforcement of privacy and consumer protection, by discouraging identity misrepresentation and theft and protecting children from harmful content by clearly informing users of means of protection, by reducing digital copyright infringement, by promoting information and network security while striking the balance between openness and security in content environments, and more generally by strengthening cross-border co-operation and practical measures to reach these goals.
- Policies that improve online commercial transactions including mechanisms for payment and micro-payments, electronic signatures and authentication, and international interoperability of these mechanisms.
- Clarifying taxation issues as they relate to digital content products.

NOTES

1 In literature, the term "serious game" is used to refer to game-like applications used in areas other than pure entertainment (see for example Abt, 2002; OECD, 2009a).

2 In 2007, for example, research firm Gartner predicted that "by the end of 2011, 80% of active Internet users (and Fortune 500 enterprises) will have a 'second life'" (*i.e.* a presence in a virtual world such as Linden Lab's *Second Life*) (Gartner, 2007). In 2009, Gartner updated its prediction, stating that virtual worlds will become mainstream in less than five years (Gartner, 2009). Forrester Research also suggested that the "3-D Internet will become as important to companies in five years as the Web is now" (Driver *et al.*, 2008).

3 On 9 March 2010, There.com was closed as a result of the financial crisis. Despite an increase in subscriber numbers and active subscribers, revenues decreased dramatically in 2009.

4 It is also interesting to note that the rise in Google's Search Index was mainly caused by people increasingly searching for "kids virtual world" and "girls virtual world" over the last years.

5 In August 2010, Intel and Nokia announced the establishment of their joint research centre for 3D mobile technology based at the University of Oulu (Finland). "The lab, which will have around two dozen researchers, will focus on mobile user experiences, with a particular emphasis on 3D experiences and technology. Likely research areas include 3D virtual worlds, 3D user interfaces and immersive gaming" (Blandford, 2010).

6 This report thereby draws on the results of the *United Kingdom-OECD Workshop on Innovation and Policy for Virtual Worlds* held in March 2009 and the conference *Virtual Policy '08* organised by the Virtual Policy Network with the support of the United Kingdom Department for Business, Enterprise and Regulatory Reform in July 2008 (see www.virtualpolicy.net/category/tvpn-event/vp08). The report also benefits from the results of the *OECD-Canada Technology Foresight Forum on the Participative Web* held in October 2007, as well as on previous OECD work on digital content including in particular on the "participative web and user-created content" (OECD, 2007) and on "online computer and video games" (OECD, 2005). It also benefited from ongoing OECD work on Internet intermediaries (see OECD, 2010c and 2010d).

7 Virtual world publishers and providers themselves, such as, for instance, Electronic Arts (publisher of *Warhammer Online*) and Blizzard Entertainment (*World of Warcraft*) rank high among the most innovative ICT firms. Electronic Arts, for example, is the largest ICT R&D spender in the ICT sector in terms of R&D intensity (35% of sales were dedicated to R&D in 2009, see OECD, 2010b).

8 See Sivan (2008) for a discussion about the relationship between virtual reality and virtual worlds.

9 The term "avatar" was first used in the context of virtual worlds by Chip Moningstar and Randy Farmer, the developers of Habitat, which is one of the first (commercial) virtual worlds (see Morningstar and Farmer, 2008).

10 Or as Bell (2008) puts it, "one can say, 'my avatar rides into the castle and slays the dragon'. Those are separate actions of the avatar. Conversely, one can't say 'My Facebook profile is emailing you'". For more details on the differences between social network sites and virtual worlds, also see Messinger *et al.*(2008).

11 This definition is consistent with that provided by Bell (2008): "a synchronous, persistent network of people, represented as avatars, facilitated by network computers". It is also consistent with the definition provided by the United States Federal Trade Commission (FTC, 2009), which states that "[o]nline virtual

worlds blend three-dimensional or 3D gaming environments with elements of online social networking, allowing their users to interact in and shape their own online content. Through avatars, virtual world users socialize, network, play, and often conduct business in graphics-intensive landscapes using text or voice chat, sounds and gestures, and video".

12 UCC is defined as: *(i)* content made publicly available over the Internet, *(ii)* which reflects a certain amount of creative effort, and *(iii)* which is created outside of professional routines and practices (see OECD, 2007). UCC can be distinguished from user-generated content (UGC), where users through their interactions (passively) generate further content.

13 The degree of UCC can be crucial for the success of virtual world as the example of Electronic Arts' *The Sims Online* reveals. After Electronic Arts discontinued its virtual world *The Sims Online* (a few months after it had been rebranded to *EA-Land*), discussions between users and bloggers about the reasons for the failure of *The Sims Online* pointed to its limitations on UCC.

14 This trend is even more pronounced when it comes to revenues with game worlds generating almost 95% of worldwide revenues related to virtual worlds according to Imagine Venture (see OECD, 2009a).

15 These numbers have to be interpreted correctly, since almost all MMOG's use 'shards', independent game server hosting parallel virtual worlds. So while thousands of players may be online at the same time, they are in parallel worlds. There are exceptions, however, such as *EvE Online*, where players are in the same virtual space.

16 Retail price may differ depending on the version. For example, the basic version of *World of Warcraft* can be purchased for USD 19.99. In contrast, *World of Warcraft Battlechest,* which includes the first expansion pack *Burning Crusade* as well as the basic version, costs USD 36.99.

Monthly subscription only includes monthly charges for the subscription with the shortest duration. For example, a month-to-month package for World of Warcraft costs USD 14.99 per month, but a three-month package USD 13.99 per month, and a six-month package USD 12.99 per month. In some cases MMOG providers may not charge any subscription fees initially to attract a critical mass of users.

17 Estimations for MMOG market values are based on PwC (2007). However, they do not include revenues from mobile (Internet)-based MMOGs, which are instead included in wireless game revenues. Moreover, they do not include revenues generated by trade in virtual items (*e.g.* skins, weapons).

18 Numbers of registered users extracted from *http://secondlife.com/xmlhttp/secondlife.php* on 01 September 2010.

19 Barnes (2007) provides a list of around 130 prominent brands in *Second Life* as of 31 August, 2007.

20 In the case of *Second Life* see *secondlife.com/statistics/economy-data.php*.

21 *secondlife.com/land/privatepricing.php*

22 It should be note, however, that these costs are very much related to a 'high end' representation in Second Life. Hosting a speaking event in Second Life, for example, can be free. The VP08 conference, for instance, organised by the Virtual Policy Network in Second Life, cost just over USD 2 000 in total, but mainly because professional camera set ups, and live video and sound recording were used.

23 Other initiatives include: the US MIT's Games to Teach; the Futurelab projects in the UK; the EC-supported Kaleidoscope (Network of Excellence), and the EC mobile M-learning project.

24 See also secondlifegrid.net/slfe/education-use-virtual-world.

25 *Alice* is "an educational software that teaches students computer programming in a 3D environment" allowing visualizing complex data models. Its narrative approach makes it easy for girls and boys to learn programming (see www.alice.org).

26 See *http://ramapoislands.edublogs.org* for further examples of virtual worlds used in schools, or *www.globalkids.org* for a project focussing on cross cultural uses of virtual spaces.

27 See *wiki.secondlife.com/wiki/Military_Lands*

28 There is also the issue of trivialisation that many people still believe that games cannot have a serious use.

29 The OECD *Declaration on Green Growth* specifically mentions the role of ICTs in meeting environmental challenges: "In order for countries to advance the move towards sustainable low-carbon economies, international co-operation will be crucial in areas such as … *application of green ICT* for raising energy efficiency" (paragraph 2); and "We recognise that special efforts need to be made at the international level for co-operation on developing clean technology, including by *reinforcing green ICT activities* …" (paragraph 8) (see OECD, 2009b).

30 *The Virtual World Conference* was held on 15 September 2010 with "21 leading international speakers from across the globe showcas[ing] innovation and applications within Virtual Worlds, debating key issues with an audience drawn from 15 countries worldwide".

31 However, at this point it is important to stress that virtual laboratories are not virtual worlds as defined in this report. Many virtual laboratories do not meet the criteria of a virtual world, that is: they do not have a *persistent computer-simulated environment allowing large number of users, who are represented by avatars, to interact in real-time with each other and the simulated environment*. However, virtual worlds can be used as a virtual laboratory.

32 Virtual world based research can be distinguished by whether phenomena inside the virtual world are the object of study (*i.e.* immersionist research) or whether real-world phenomena are being analysed based on virtual worlds as experimental platforms (*i.e.* augmentationist research). In the context of social sciences, "immersionist research refers to research within virtual worlds from the residents' perspective, [while] augmentationist research explores how real-world enterprises and individuals use virtual worlds to achieve their strategic goals" (Altas, 2008).

33 It should be noted, however, that there are generally no more than 70 000 users connected in virtual worlds such as *Second Life.*

34 The Finnish Children's parliament is an interesting experiment that is using virtual worlds and which is related to developing awareness for citizen participation (see *www.lastenparlamentti.fi/in_english).*

35 See *http://secondhealth.wordpress.com/*

36 Although making a virtual tour inside a museum or gallery is not new, the experience of sharing the visit with others is only possible through virtual worlds as defined in this report.

37 It should also be noted that some virtual collections such as the "Second Louvre", a virtual representation of the Parisian Louvre inside of *Second Life*, have no official ties to the original collection.

38 Advertised speeds are typically the theoretical maximum for the employed technologies. Users commonly have lower speeds. Also, often only certain parts of a given country have access to these speeds.

39 It is interesting to note that about 50% of these MMORPG players work full-time, about 36% are married, and 22% have children.

[40] There are extreme cases of people p1aying MMORPGs for more than 8 hours a day and by doing so earning (real-life) revenues of more than USD 2 000 a month (see Sang-Hun, 2010).

[41] In Korea, for example, almost 51% of men are playing video games for more than 3 hours per day compared to 46% of all women (Ministry of Culture and Tourism and the Korean Game Industry Agency, 2006).

[42] See *OECD Policy Guidance for Digital Content*, adopted at the Seoul Ministerial on the Future of the Internet Economy, Seoul, Korea, 17-18 June 2008 (see digital content principles in Annex 2)

[43] According to most-expensive.com, *Shenmue* (published by Sega for its game console Dreamcast) was the most expensive game ever, with development costs of USD 20 billion and seven years of development.

[44] Habitat, created in 1985 by Lucasfilm Games and Quantum Computer Services, was one of the first (commercial) virtual worlds, which could support a population of thousands of users.

[45] See *http://www.e426.org/IEEE/*

[46] The Virtual Policy Network (2011) defines 'gold farming' as "[…] the professional use of online game to generate income. […] While the term suggests that this is just online currency, gold farming includes many types of virtual items and also services such as 'character levelling', where someone pays another person to play the game for them". It should be noted, that many of these activities are usually prohibited by the terms of service of many majors MMOGs and can lead to the banning of the seller and sometimes of the buyer as well.

[47] See also Figure 5 showing that the total value of user-to-user transactions in *Second Life* was more than half a USD billion in 2009 and is continuing to increase rapidly.

[48] The inability to use widely available e-cash solutions such as *e.g. PayPal* for payment in virtual worlds in favour of local virtual currencies is an example of how the lack of (*de facto*) standards prevents the interoperability of virtual worlds. For more on the role of Internet intermediaries to promote e-cash solutions, see OECD (2010c and 2010d).