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Executive Summary

This report is a European-wide study on various topics centered on the use of virtual worlds and ICT for education and issue associated with it. The report contains an overview of:

- Game-Based Learning & Gamification for 3D Virtual Learning Environments
- ICT in Education Practices around Europe
- Special educational needs of vulnerable users and the prevention of digital exclusion

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1. Game-Based Learning & Gamification for 3D Virtual Learning Environments

1.1. Introduction to Game-Based Learning and gamification

Game-Based Learning (GBL)—also abbreviated as DGBL (Digital Game-Based Learning) when digital games are used—is usually associated with the terms *gamification*, *edutainment*, or *Serious Games*. Considering this diversity of names, several definitions have also been proposed. Prensky (2001) introduced and described GBL as the *marriage* of educational content and computer games. Deterding *et al.* (2011) refer to gamification as the use of game design elements in non-game contexts. Anikina & Yakimenko (2015) define edutainment as the implementation of technological innovations (e.g., multimedia, computer software) in traditional education, where games whose first purpose is not mere entertainment (Michael & Chen, 2006) are introduced, aiming to support learning in its broadest sense (Stone, 2008) and, are hence, classified as serious. Whatever definition is opted for, the main idea of this approach remains the same: *students learn through the game instead of how to play the game* (Wu *et al.*, 2011). Therefore, the essence of this model is to invoke psychological experiences—similar to the ones that games do through their rich and visual appealing aesthetics—and motivate learners to engage with the learning activities (Huotari & Hamari, 2012; Poole, 2000).

Bober (2010) distinguishes GBL activities into two main categories: *(1)* learning directly from [playing] the game (constructivist approach) and *(2)* learning from teacher-driven activities related to the game (instructional approach). Proponents of active construction (Aldrich, 2009; Bouras *et al.*, 2004; David & Watson, 2008; Gee, 2003; Kiili, 2005; Mawdesley *et al.*, 2011) emphasise the opportunities offered to learners to practice the so-called soft skills (e.g., decision making, problem solving, communication, collaboration, team work) that cannot be easily taught in isolation. Those soft skills can, however, be practiced through *coopetition*—collaboration with group members and competition between groups—(Fu & Yu, 2008; Ke & Grabowski, 2007) or *player-learner* experience (Warburton, 2009).

On the other hand, others (Bopp, 2006; Gibson, 2006; Van Eck, 2010) consider it essential to employ pedagogical and instructional approaches, so as to maximise the learning benefits and outcomes. Prensky (2001) bridges these viewpoints and suggests that the consequences of trial and error (failure to achieve the game's goals) can be transformed or translated into feedback on and explanation of the learners' actions (through the use of instructional material). This way, students are enabled to evaluate their decisions. The aforementioned studies grounded the development of frameworks (e.g., de Freitas & Oliver, 2006) that have also been employed in conjunction with other established learning models (e.g., Arnab *et al.*, 2011; de Freitas & Neumann, 2009; White *et al.*, 2007).

This bridging has resulted in a great number of positive outcomes, especially on motivation and engagement, compared to just employing traditional learning techniques (Carnevale, 2003; Kim & Ke, 2017; Kim, Park & Baek, 2009; Knight *et al.*, 2010; Xu, Park & Baek, 2011; Young *et al.*, 2012; Zyda, 2005). However, despite the reported benefits and applications of GBL, researchers still maintain a high degree of scepticism towards its effectiveness on the learning process. Indeed, balancing between playability and pedagogy is a rather challenging task that educators and instructional designers ought to consider carefully and sensibly (Baek & Kim, 2005; Kim *et al.*, 2009).

Even though GBL is yet another example of student-centered learning model, Garris, Ahlers & Driskell (2002) suggest that teachers should not isolate themselves from the learning process, but instead opt to foster participation and engagement through direction and support. Van Eck (2007) advises educators to blend the game elements with the instructional activities, so as to extend the context of the game into the physical classroom. Pivec, Dziabenko & Schinnerl (2004) list a set of factors that educators have to consider before adopting a game-based approach. One such factor is the development of a clear understanding of the subjects that GBL can support, as well as of the skills that can be developed in order to benefit learners. Another factor is the identification of the most suitable game for a given subject, as well as of the learning stage and the instructional method that should be deployed. As Deterding *et al.* (2011) suggest, gamified activities should be implemented with the same affordances required to design and develop virtual games in order to motivate and engage learners. Nevertheless, given that the psychological characteristics or affordances that stem from games are not explicitly identified, various instructional design approaches are framed under the gamification idea (Hamari, Koivisto & Sarsa, 2014).

1.2. Game-Based Learning and gamification in education

Virtual worlds provide not only the necessary context for all the aforementioned interactions, but they are also increasingly providing more complex interactions. Both these facts have led educators to use them extensively, taking into account all their educational potentials (Schrader, 2008). A search query across different scientific databases related to “3D Educational Virtual Worlds” returned almost 5.500 results of which, 674 discuss implementations and findings emerging from efforts that have integrated GBL and gamification scenarios. As a matter of fact, the trend analysis (Fig. 1) illustrates the increasing interest that researchers and educators have toward this direction which is justified after considering the widespread use of 3D Virtual Learning Environments and the added value of such didactic approaches.

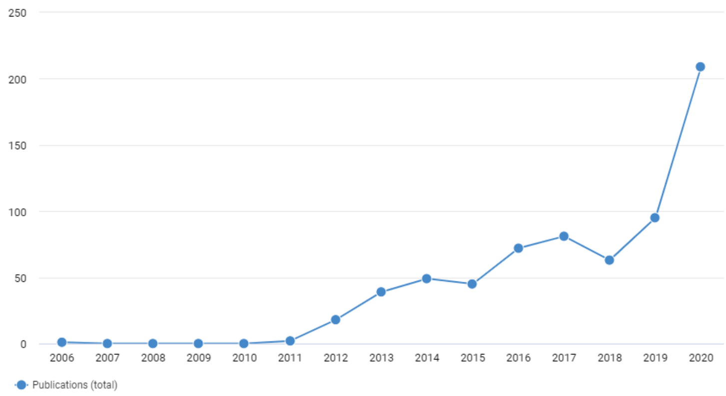


Figure 1. Trend analysis of manuscripts discussing integrations of GBL scenarios in 3D Virtual Worlds.

1.3. Planning the lessons with gamified elements

The complex and multifaceted nature of game engineering involves multidisciplinary work (e.g., design, programming, psychology) and that makes it hard to design them; let alone blending such mechanisms with educational concepts and transferring them into 3D Virtual Learning Environments. To mitigate this burden, Prensky (2001) provides an exhaustive list of elements that DGBL instructional designers and educators should consider when preparing such interventions. On the grounds of his work, we present and elaborate the themes that should be considered when designing gamified interventions for 3D Virtual Worlds.

- ***Mechanism***: The *'game mechanism'* is considered to be the most important factor as it describes the methods and the techniques that will be utilised to achieve the design goals (Schell, 2008). Any decisions made in this phase should be implemented with careful consideration as they will naturally affect the educational value of the end product. For instance, educational games which aim at fostering player cooperation may involve the integration of functions which support group interaction. Single-player educational games may involve virtual rewards or scores.
- ***Rules***: All the interactions and conflicts that the educational game presents should be detailed under the *'game rules'* as they influence learners' motivation and satisfaction (Coutinho *et al.*, 2015). Clearly predefined rules can guide and assist learners to finish the game (Laamarti & El Saddik, 2014). For instance, if the students should follow a specific path, hints should be displayed on the screen so that they can explore the map. Likewise, special operation modes may be integrated to determine students' progress and provide feedback.
- ***Narrative***: The *'game narrative'* describes what happens during the interaction time. There are many ways to communicate the game narrative (e.g., text, multimedia) but the end goal remains the same; it should present a story that involves substantial challenges and opportunities for the learners to unfold their existing

or newly acquired knowledge. Likewise, the degree of importance varies and depends greatly on the game genre. For instance, a simulation or a puzzle game may require quick actions from the end-user with possible time constraints. On the other hand, an exploration game includes storyline elements and thus, may be required more time to complete.

- ***Goals***: The *'game goals'* are yet another core concept that designers should consider. During the preparation phase, the elements of the learning content should be detailed and the educational objectives should be explicitly mentioned. Accordingly, the intercorrelations between the aforementioned aspects and the game narrative should be identified and aligned with the narrative of the learning experience (Kiili, 2005).
- ***Challenges***: Achieving the game goals requires exert effort. In this context, *'game challenges'* do not necessarily consist a learning factor but remain one of the key-elements that motivate players to engage (Gee, 2003; Malone, 1981). As a result, well-designed educational challenges, with gradual increase of the difficulty level, can facilitate the attainment of the (learning) goals and influence positively the cognitive and affective outcomes of learners (Rieber & Noah, 2008; Westera *et al.*, 2008).
- ***Outcomes***: All the aforementioned design elements are collectively contributing to one particular goal; the attainment of meaningful and thorough *'learning outcomes'*. Regardless of the chosen method or approach to evaluate the effectiveness of the intervention (i.e., inside or outside the Virtual World), educators and instructional designers should ensure that evidence is collected with regard to the knowledge and skills' gains that students have realised both after the completion of the learning activities (immediate evaluation) and over the course of time (retention evaluation). It is also important to ensure that, when *hands-on* activities are simulated within the virtual environment students have acquired the necessary understanding to *transfer* the acquired skills in the real-world context (i.e., empirical evaluation).

Considering the above, it can be concluded that in order for such interventions to be efficient and effective, the learning concepts should be translated into gameplay elements and vice versa. Under this consideration, Arnab *et al.* (2015) enlist and illustrate the connection points between the 'Learning' and the 'Game' mechanics that instructional designers and educators should consider when developing (Digital) Serious Games. Based on this list, we provide an overview of the most relevant and applicable, to 3D Virtual Learning Environments, approaches accompanied by indicative examples (Tables 1-2).

Table 1. Learning Mechanics applicable to 3D Virtual Learning Environments.

#	Mechanic	Description	Examples	Implementation
Learning Mechanics	Simulation Experimentation	Learners immerse themselves in virtually authentic scenarios which enable them to actively participate in activities that involve hypotheses' examination and experience situations that would otherwise be impossible to do in the real world.	Virtual Laboratories	Content Creation (Instructor) Avatars; Chat
	Exploration Observation	Learners acquire knowledge passively by exploring the available content and observing theory-related matters which enable them to gather information about real-world phenomena.	Virtual Fieldworks	Content Creation (Instructor) Avatars; Chat
	Analyse Discuss / Reflect	Learners use their existing knowledge and skills to make sense of a situation. Accordingly, their choices and decisions transform the play scene and define the outcome of the given scenario. Upon completion of the activity, they discuss and reflect on the results of their actions.	Virtual Quests; Problem Solving	Content Creation (Instructor) Avatars; Chat
	Ownership Accountability	Learners develop their creativity skills by utilising the available technical tools to create and animate authoring virtual content or solutions to given problems.	Content Design / Programming Project Development / Management	Authoring Tools (Students) Avatars; Chat
	Tutorial - Assessment	Learners construct their knowledge by researching and answering challenging questions.	Quizzes; Logic Puzzles	Content Creation (Instructor) Avatars; Chat; NPC

Table 2. Game Mechanics applicable to 3D Virtual Learning Environments.

#	Mechanic	Description	Examples	Requirements
Game Mechanics	Collaboration Cooperation	Learners engage in group-/pair-based activities, via their virtual personas, and enact their knowledge collectively through information exchange, meaning negotiation, and active participation in procedural activities.	Exploration; Co-creation; Group Discussion / Debate; Problem-solving; Project work	Content Creation (Instructor / Students) Avatars; Chat
	Role-Play	Learners engage in simulated scenarios, via their virtual personas, which enable them to experience the knowledge and increase their awareness/understanding of different processes.	Real-Life Activities; Historical Events; Imaginary Scenarios	Content Creation (Instructor / Students) Avatars; Chat; NPC
	Competition	Learners are faced with scenarios that involve a series of academically meaningful challenges. Such scenarios are usually implying strict time-frames and may involve collaboration with other students.	Scavenger Hunt; Virtual Escape Room; Mystery Solving	Content Creation (Instructor) Avatars; Chat; NPC
	Cascading Information	Learners receive clues, information, and guidance related to the features of the Virtual World or the subject under investigation. Such cues mitigate the impact of the learning curve and facilitate the knowledge/skills advancement.	Info Spots; Noticeboards; Notecards; NPC	Content Creation (Instructor) NPC
	Rewards	Learners receive virtual rewards (e.g., tokens, goods, information) based on their performance, progress, and outcomes.	Leaderboards; Tokens; Goods; Information; NPC	Content Creation (Instructor) NPC

1.4. Good practices

For the generic setup of the virtual learning environment, space division might come handy, especially when it is structured to guide learners around the Virtual World's space and inform them about its functions. Some examples (Figure 3) of the development plan that Karakus *et al.* (2016) utilised include the integration of: *(a)* an information house (using audiovisual material such as boards, posters, videos), *(b)* clothing areas (with premade outfits for editing/modification of avatars' appearance), *(c)* spaces for exercise/practice in order to increase the learners' confidence and familiarity with the world, *(d)* a reward system with self-evaluation components to boost the learners' motivation, satisfaction and satisfy their game-like expectations, and *(e)* socialisation/entertainment areas with featured game-related objects (e.g., swings, teeter-totters, campsites).

Figure 2. Snapshots of different orientation areas developed in Second Life (Karakus et al., 2016).

Konstantinidis *et al*. (2010) enhanced and promoted the collaborative elements that such environments offer by introducing concepts based on the Jigsaw (cooperation by design) and the Fishbowl (formation of concentric circles for in-depth discussions and presentations) techniques (Figure 3). In both approaches the aim was: *(a)* to facilitate interaction among students (both in the virtual and in the physical environment), *(b)* to encourage collaboration and active involvement of all members in the problem-solving process, and, therefore, *(c)* to increase motivation and engagement.

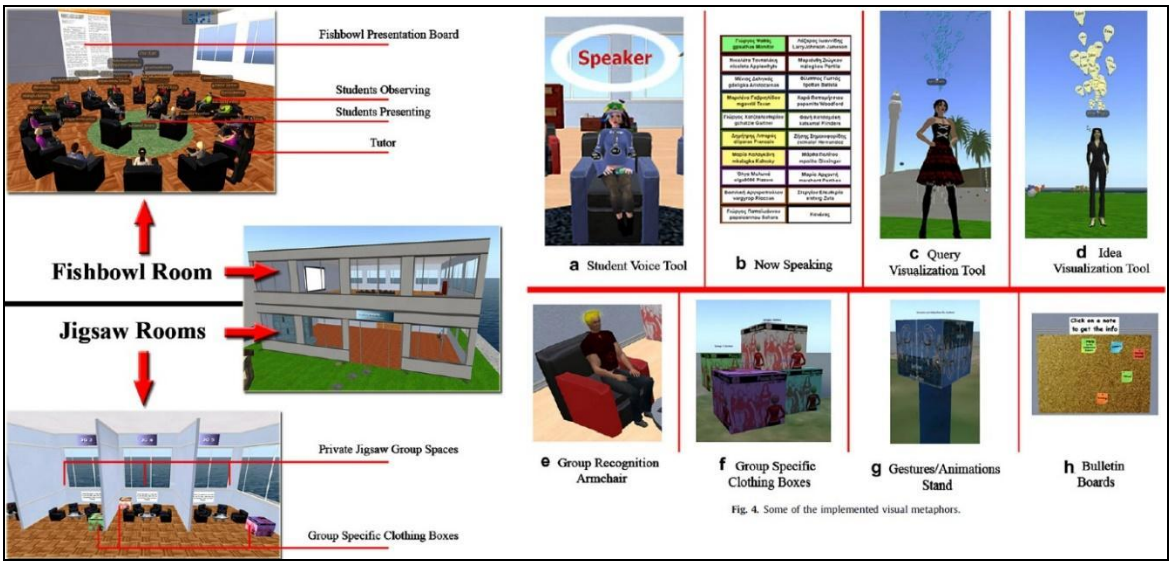


Figure 3. Integration of Jigsaw and Fishbowl collaborative learning techniques in 'Second Life'.

Bredl *et al.* (2012) introduced adventure games to help learners consolidate the knowledge and assess their understanding. In the first example (Figure 4) the authors transformed the course "Introduction to the Methods of Empirical Communication Research" into a storyline of fairytales (e.g., Magic Garden, Sleeping Beauty's Castle, the Gingerbread House, Rapunzel's Tower). Participating students undergone through various exploration tasks which involved knowledge-based challenges and decision making.

Figure 4. Exploratory learning via questing (Bredl et al., 2012)

Another simulation prepared by Bredl *et al.* (2012) concerned the training of emergency professionals (police, rescue services) in emergency response situations (natural disasters, car accidents, fire outbreaks, floods).

Professionals engaged in these simulations were expected to utilise their formal training to inform their decisions and respective actions (time-dependent problem solving). Participants were receiving additional information about the given scenario via virtual ‘notecards’ whereas, to make the experience more realistic, the use of dedicated equipment was introduced. In addition, the ‘Health Points’ system was enabled indicating exposure to hazards and other similar factors.

Figure 5. Emergency response disaster training programme in Second Life (Bredl et al., 2012).

Loula *et al.* (2014), ‘transformed’ students into reptiles in the context of an ecological survivability simulation. Participating students were grouped in pairs and immersed themselves in a multistage procedural storyline which included formation of different hypotheses related to the survival difficulties faced by the lizards and the various challenges they face due to the environmental changes. Upon completion of the simulation students articulated their experiences and discussed their observations.

Figure 6. Contexts and situations that reptiles face natural threats (Loula et al., 2014).

Barab *et al.* (2012) developed a custom 3D Virtual Learning environment which enabled students to engage in different exploration activities (Figure 7). In the context of this process, the students were acting as 'persuasive writers' wherein their decisions and choices were altering the game narrative (transformational play). Along with the development of their virtual character the students were recording their chooses on the basis of which they prepared and submitted for evaluation a persuasive essay (external task).

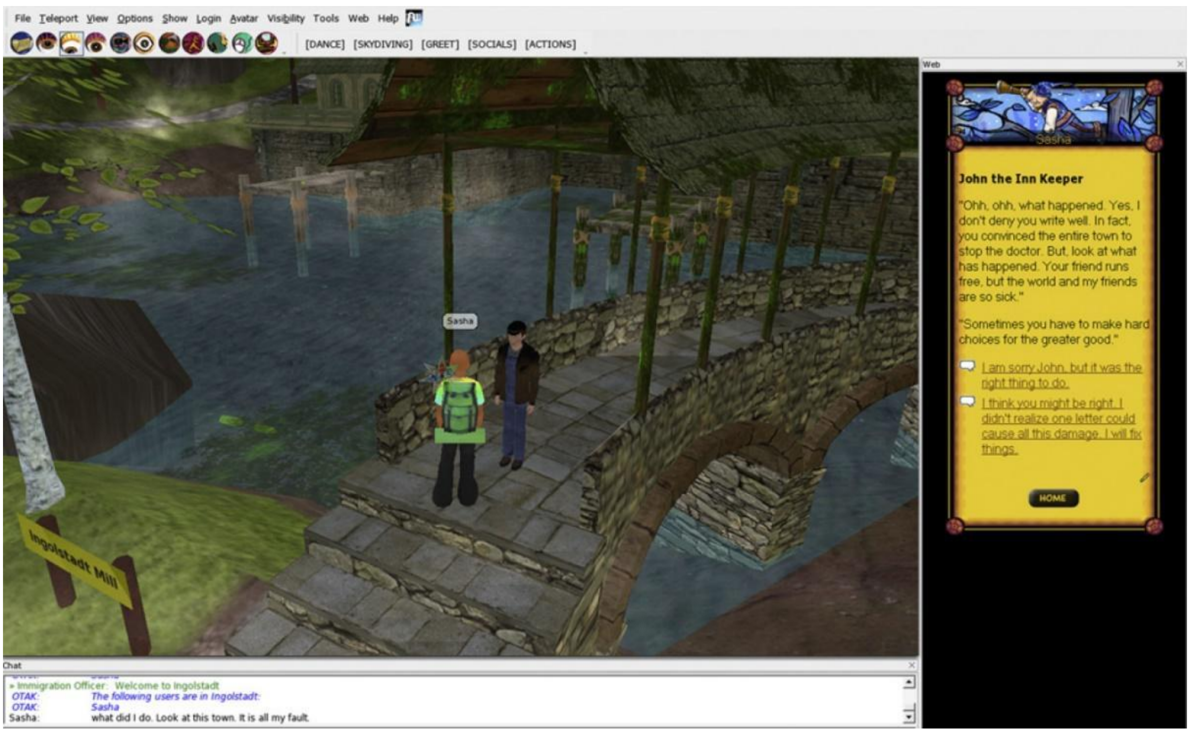


Figure 7. Students' decisions influencing the narrative of the in-game events and endings (Barab et al., 2012).

Pellas & Vosinakis (2018) engaged their students in processes that aimed at improving their Computational Thinking skills by introducing activities which involved 3D prototype modeling and programming. In this scenario the OpenSimulator technology was used for the 3D modeling together with the 'Scratch4OpenSim' (external plugin) for the scripting/programming needs. Students initially designed their solutions offline and accordingly simulated them in the provided environment.

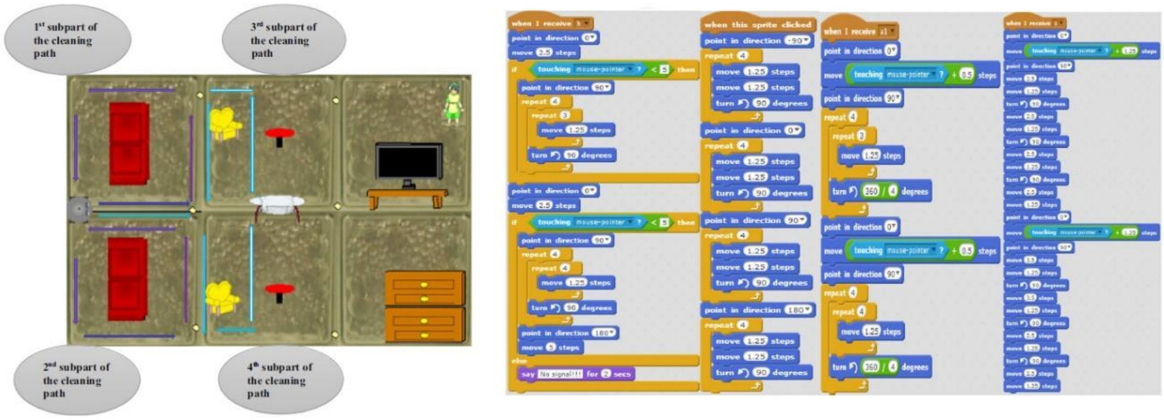


Figure 8. Integration of third-party software (Scratch4OpenSim) to animate 3D prototypes (Pellas & Vosinakis, 2018).

Moon *et al.* (2020) explored the potential of OpenSimulator in the context of special education where adolescents within the autism spectrum undertook problem-solving activities related to STEM education (Figure 9, upper).

Young *et al.* (2012), turned the Second Life Virtual World into a 'canvas' by enabling students to present the findings of their research in the form of digital posters (Figure 9, lower frame)

Figure 9. Students within the autism spectrum engage in different problem-solving tasks (upper frame) (Moon et al., 2020). Students present the findings of their research in the context of a virtual gallery (lower-frame) (Young et al., 2020).

Nelson (2007) developed an educational game which enabled students to undertake the role of 'scientists' thus, allowing them to examine different hypotheses and scenarios via collaborative experimentation and practicing. To facilitate the learning process and support learners achieve their goals, a guidance system was embedded together with a chat-tool.

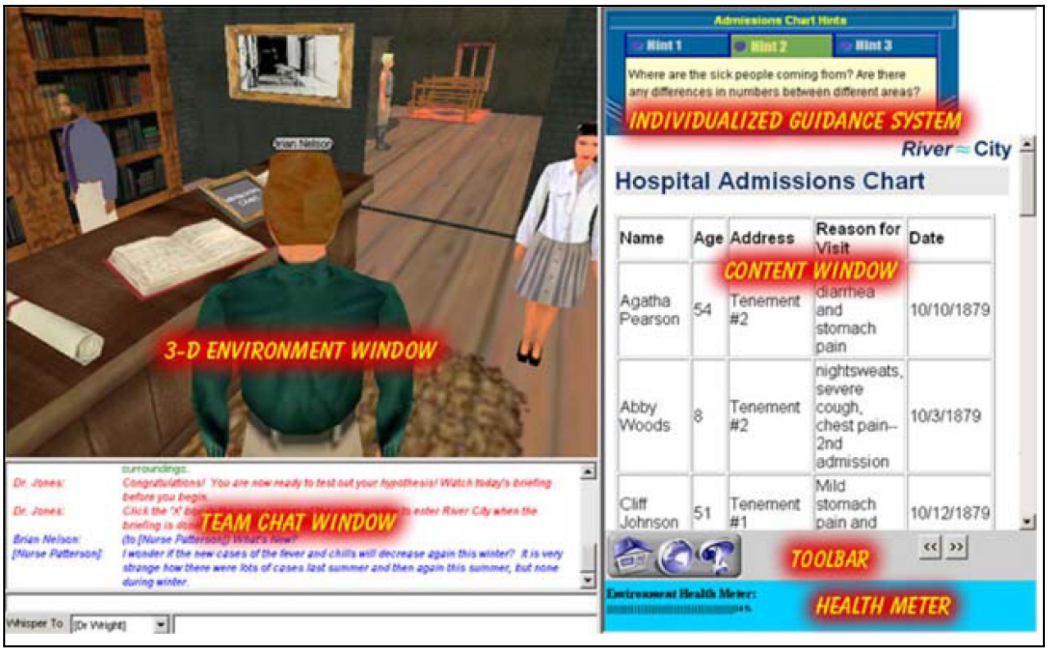


Figure 10. Medical Education simulation (Nelson, 2006).

Finally, Şimşek (2016) improved the learning experience by adding Non-Player Characters (Pedagogical Agents) to offer additional guidance and support to learners undertake and complete different tasks in mathematics and geometry.

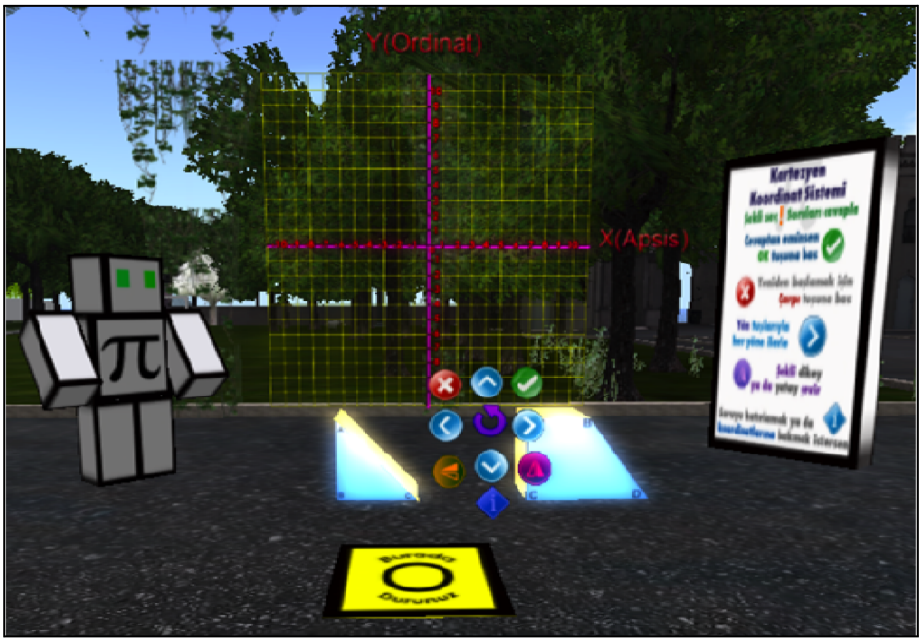


Figure 11. Mathematic robot and exercises in Second Life (Şimşek, 2016).

For the evaluation of the educational outcomes, researchers and educators are utilising a variety of methods ranging from quantitative (e.g., surveys, tests) to qualitative (observation, audiovisual recordings) or even a combination of both (mixed-methods). In most studies, the following topics were under investigation: *(a)* motivation for learning, *(b)* learner engagement, *(c)* learning performance, and *(d)* learning experience. Table 3 provides an overview of the studies which have explored the benefits that 3D Virtual Worlds offer in education followed by a brief discussion. Table 3 provides an overview of the outcomes of the abovementioned interventions.

Table 3. Overview of the evaluation results of gamified educational Virtual Worlds.

Outcome	Study
Enhancement of learning motivation	Loula *et al.*, 2014; Young *et al.*, 2012
Improvement of learner engagement & active participation	Barab *et al.*, 2012; Konstantinidis et al., 2010; Moon et al., 2020
Improvement of learners' performance	Pellas & Vosinakis, 2018; Şimşek, 2016; Bredl et al., 2012
Positive attitude toward Virtual Worlds for educational practices	Şimşek, 2016

2. ICT in Education Practices around Europe

2.1. Digital Action Plan

The Digital Education Action Plan (2021-2027) outlines the European Commission's vision for high-quality, inclusive, and accessible digital education in Europe. It is a call to action for stronger cooperation at European level to[1]:

1. learn from the COVID-19 crisis, during which technology is being used at an unprecedented scale in education and training;

[1] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en

2. make education and training systems fit for the digital age.

The new Action Plan has two strategic priorities:

1. **Fostering the development of a high-performing digital education ecosystem**

This requires:

- infrastructure, connectivity and digital equipment;
- effective digital capacity planning and development, including up-to-date organisational capabilities;
- digitally competent and confident teachers and education and training staff
- high-quality learning content, user-friendly tools and secure platforms which respect privacy and ethical standards.

2. **Enhancing digital skills and competences for the digital transformation**

This needs:

- **basic digital skills and competences** from an early age:
  - digital literacy, including fighting disinformation;
  - computing education;
  - good knowledge and understanding of data-intensive technologies, such as artificial intelligence;
- **advanced digital skills** which produce**:**
  - more digital specialists;
  - ensure that girls and young women are equally represented in digital studies and careers.

2.2. The Digital Competence Framework 2.0

DigComp 2.0 identifies the key components of digital competence in 5 areas which can be summarised as below[2]:

1) **Information and data literacy**: To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage, and organise digital data, information and content.
2) **Communication and collaboration**: To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one's digital identity and reputation.
3) **Digital content creation**: To create and edit digital content To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licences are to be applied. To know how to give understandable instructions for a computer system.
4) **Safety**: To protect devices, content, personal data and privacy in digital environments. To protect

[2] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-20-digital-competence-framework-citizens-update-phase-1-conceptual-reference-model

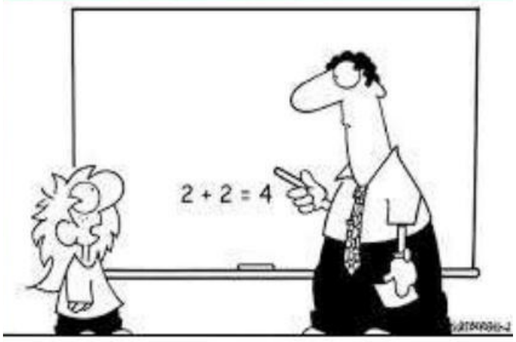
physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.

5) **Problem solving**: To identify needs and problems, and to resolve conceptual problems and problem situations in digital environments. To use digital tools to innovate processes and products. To keep up-to-date with the digital evolution.

[3]

[3] https://www.schooleducationgateway.eu/en/pub/resources/tutorials/digital-competence-the-vital-.html

Key issues to remember in relation to the importance of ICT in Education are that:[4]



How can I trust your information when you are using such outdated technology?

1. **E-learning or Online Learning:** The presence of ICT in education allows for new ways of learning for students and teachers. E-learning or online learning is becoming increasingly popular and with various unprecedented events taking place in our lives, this does not only open opportunities for schools to ensure that students have access to curriculum materials whilst in the classroom but also allows them to ensure students outside the classroom such as at home or even in hospitals can learn.
2. **ICT brings inclusion:** The benefits of ICT in education is of such that students in the classroom can all learn from the curriculum material. Students with special needs are no longer at a disadvantage as they have access to essential material and special ICT tools can be used by students to make use of ICT for their own educational needs.
3. **ICT promotes higher-level thinking skills:** One of the key skills for the 21st century which includes evaluating, planning, monitoring, and reflecting to name a few. The effective use of ICT in education demands skills such as explaining and justifying the use of ICT in producing solutions to problems. Students need to discuss, test, and conjecture the various strategies that they will use.
4. **ICT enhances subject learning**: It is well known these days that the use of ICT in education adds a lot of value to key learning areas like literacy and numeracy.
5. **ICT use develops ICT literacy and ICT Capability:** Both are 21st-century skills that are best developed whilst ICT remains transparent in the background of subject learning. The best way to develop ICT capability is to provide them with meaningful activities, embedded in purposeful subject-related contexts.
6. **ICT use encourages collaboration:** You just have to put a laptop, iPad or computer in the classroom to understand how this works. ICT naturally brings children together where they can talk and discuss what they are doing for their work and this in turn, opens up avenues for communication thus leading to language development.
7. **ICT use motivates learning:** Society's demands for new technology has not left out children and their needs. Children are fascinated with technology and it encourages and motivates them to learn in the classroom.
8. **ICT in education improves engagement and knowledge retention:** When ICT is integrated into lessons, students become more engaged in their work. This is because technology provides different opportunities to make it more fun and enjoyable in terms of teaching the same things in different ways. As a consequence of this increased engagement, it is said that they will be able to retain knowledge more effectively and efficiently.
9. **ICT use allows for effective Differentiation Instruction with technology:** We all learn differently at different rates and styles and technology provide opportunities for this to occur.

[4] https://www.ictesolutions.com.au/blog/why-schools-should-invest-in-ict/

10. **ICT integration is a key part of the national curriculum:** The integration of digital technologies or ICT is a one of the priorities of European Union, and this is a **trend** that many national/local governments are taking up as they begin to see the significance of ICT in education.

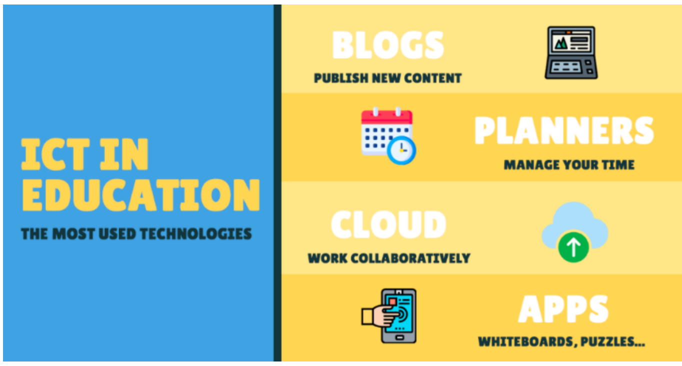
Importance of Students Engaging with ICT

It is important for students to engage with ICT so that:

1. Learn 21st-century skills and develop their ICT capability and ICT literacy.
2. Improves their attainment levels.
3. Prepares them for an integrated society dominated by ICT developments.
4. So that they learn the notion of using ICT as a tool for lifelong learning.

If you put a lot of thought into your planning, you will notice a higher degree of engagement and this can lead to the development of 21st-century skills such as complex thinking, creative problem-solving, and collaboration.

Technology integration in the classroom is an **instructional choice** by you, the teacher, and should always involve collaboration and deliberate planning [5].



Source of picture[6]

[5] https://www.openlearning.com/ictesolutions/courses/integrateeffectiveteach/?cl=1

[6] https://pedagoo.com/uses-of-ict-in-education/?lang=en

2.3. What are the most used technologies in the classroom[7]?

- **Blogs and social networks:** it gives us the possibility of creating work groups where students expose or discuss different topics, publish content related to the subjects, etc.
- **Planning through tools:** calendars and task managers are very useful to schedule exams, deliveries, create workflows, etc.
- **Data storage in the cloud:** it allows us the possibility of working collaboratively, accessing from any device and from any place. Some of the tools that use this technology are office packages, storage, etc.
- **Digital whiteboards and interactive tables:** whiteboards allow projecting and controlling images from a computer, making notes and comments, and saving and / or sending the screen by email. The interactive tables give the possibility for the students to interact directly with the surface.

In the case of e-learning platforms such as **Pedagoo, Docebo**, **Adobe Captivate, Google Classroom etc.**[8], the total digitization of the assessment is added, including thousands of exam questions, detailed student progress, standardization of assessments or creation of workflows.

2.4. Issues and Discussion[9]

Digital culture and digital literacy: Computer technologies and other aspects of digital culture have changed the ways people live, work, play, and learn, impacting the construction and distribution of knowledge and power around the world. Graduates who are less familiar with digital culture are increasingly at a disadvantage in the national and global economy. Digital literacy—the skills of searching for, discerning, and producing information, as well as the critical use of new media for full participation in society—has thus become an important consideration for curriculum frameworks.

In many countries, digital literacy is being built through the incorporation of information and communication technology (ICT) into schools. Some common educational applications of ICT include:

- *One laptop per child:* Less expensive laptops have been designed for use in school on a 1:1 basis with features like lower power consumption, a low cost operating system, and special re-programming and

[7] https://pedagoo.com/uses-of-ict-in-education/?lang=en

[8] https://axiomq.com/blog/10-best-examples-of-elearning-platforms-today/

[9] https://learningportal.iiep.unesco.org/en/issue-briefs/improve-learning/curriculum-and-materials/information-and-communication-technology-ict

mesh network functions. Despite efforts to reduce costs, however, providing one laptop per child may be too costly for some developing countries.

- *Tablets:* Tablets are small personal computers with a touch screen, allowing input without a keyboard or mouse. Inexpensive learning software ("apps") can be downloaded onto tablets, making them a versatile tool for learning. The most effective apps develop higher order thinking skills and provide creative and individualized options for students to express their understandings.
- *Interactive White Boards or Smart Boards*: Interactive white boards allow projected computer images to be displayed, manipulated, dragged, clicked, or copied. Simultaneously, handwritten notes can be taken on the board and saved for later use. Interactive white boards are associated with whole-class instruction rather than student-centred activities. Student engagement is generally higher when ICT is available for student use throughout the classroom.
- *E-readers*: E-readers are electronic devices that can hold hundreds of books in digital form, and they are increasingly utilized in the delivery of reading material. Students—both skilled readers and reluctant readers—have had positive responses to the use of e-readers for independent reading. Features of e-readers that can contribute to positive use include their portability and long battery life, response to text, and the ability to define unknown words. Additionally, many classic book titles are available for free in e-book form.
- *Flipped Classrooms:* The flipped classroom model, involving lecture and practice at home via computer-guided instruction and interactive learning activities in class, can allow for an expanded curriculum. There is little investigation on the student learning outcomes of flipped classrooms. Student perceptions about flipped classrooms are mixed, but generally positive, as they prefer the cooperative learning activities in class over lecture.

2.5. The Uses of ICTs in Education[10]

Each of the different ICTs—print, audio/video cassettes, radio and TV broadcasts, computers or the Internet—may be used for presentation and demonstration, the most basic of the five levels. Except for video technologies, drill and practice may likewise be performed using the whole range of technologies. On the other hand, networked computers and the Internet are the ICTs that enable interactive and collaborative learning best; their full potential as educational tools will remain unrealized if they are used merely for presentation or demonstration.

ICTs stand for information and communication technologies and are defined, for the purposes of this primer, as a "diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information."[11]

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[10]

https://en.wikibooks.org/wiki/ICT_in_Education/The_Uses_of_ICTs_in_Education#How_have_computers_and_the_Internet_been_used_for_teaching_and_learning?

[11] 4 Blurton,C.,"New Directions of ICT-Use in Education". Available online http://www.unesco.org/education/educprog/lwf/dl/edict.pdf;accessed 7 August 2002.

These technologies include computers, the Internet, broadcasting technologies (radio and television), and telephony. to be used and their modalities of use.

2.5.1. Teleconferencing and how can be use in educational process?

Teleconferencing refers to **interactive electronic communication among people located at two or more different places**.[12] There are four types of teleconferencing based on the nature and extent of interactivity and the sophistication of the technology:

- audioconferencing,
- audio-graphic conferencing,
- videoconferencing,
- Web-based conferencing.

Audioconferencing involves the live (real-time) exchange of voice messages over a telephone network. When low-bandwidth text and still images such as graphs, diagrams or pictures can also be exchanged along with voice messages, then this type of conferencing is called audiographic. Non-moving visuals are added using a computer keyboard or by drawing/writing on a graphics tablet or whiteboard.

Videoconferencing allows the exchange not just of voice and graphics but also of moving images. Videoconferencing technology does not use telephone lines but either a satellite link or television network (broadcast/cable). Web-based conferencing, as the name implies, involves the transmission of text, and graphic, audio and visual media via the Internet; it requires the use of a computer with a browser and communication can be both synchronous and asynchronous.

Teleconferencing is used in both formal and non-formal learning contexts to facilitate teacher-learner and learner-learner discussions, as well as to access experts and other resource persons remotely. In open and distance learning, teleconferencing is a useful tool for providing direct instruction and learner support, minimizing learner isolation.

[12] Rao,V.Rama,"Audio Teleconferencing—A Technological Prescription for Interactive Learing";available from http://www.clrec.org/rama; accessed 14 August 2002.

2.5.2. Computers and the Internet and how can be use in educational process?

There are three general approaches to the instructional use of computers and the Internet, namely[13]:

- Learning **about** computers and the Internet, in which technological literacy is the end goal;
- Learning **with** computers and the Internet, in which the technology facilitates learning across the curriculum; and
- Learning **through** computers and the Internet, integrating technological skills development with curriculum applications use for doing different kind of research.

Learning about computers and the Internet focuses on developing technological literacy. It typically includes:

- Fundamentals: basic terms, concepts and operations;
- Use of the keyboard and mouse;
- Use of productivity tools such as word processing, spreadsheets, data base and graphics programs;
- Use of research and collaboration tools such as search engines and email;
- Basic skills in using programming and authoring applications;
- Developing an awareness of the social impact of technological change.

Learning with the technology means focusing on how the technology can be the means to learning ends across the curriculum. It includes:

- Presentation, demonstration, and the manipulation of data using productivity tools;
- Use of curriculum-specific applications types such as educational games, drill and practice, simulations, tutorials, virtual laboratories, visualizations and graphical representations of abstract concepts, musical composition, and expert systems;
- Use of information and resources (usually) online such as encyclopedia, interactive maps and atlases, electronic journals and other references;
- Technological literacy is required for learning with technologies to be possible, implying a two-step process in which students learn about the technologies before they can actually use them to learn.

Learning through computers and the Internet combines learning about them with learning with them. It involves learning the technological skills "just-in-time" or when the learner needs to learn them as he or she engages in a curriculum-related activity. For example,

[13] Richmond, Ron. Integration of Technology in the Classroom: An Instructional Perspective. SSTA Research Centre Report #97-02; available from http://www.ssta.sk.ca/research/technology/97-02.htm#BIBLIOGRAPHY; accessed 30 October 2002.

secondary school students who must present a report on the impact on their community of an increase in the price of oil for an Economics class may start doing research online, using spreadsheet and database programs to help organize and analyze the data they have collected, as well using word processing application to prepare their written report. Therefore, learning through computer is a vital way to be defined as ICT, adhered to computer literacy.

2.5.3. Telecollaboration

Online learning involving students logging in to formal courses online is perhaps the most commonly thought of application of the Internet in education during the last few months. However, it is by no means the only application. Web-based collaboration tools, such as email, listservs, message boards, real-time chat, and Web-based conferencing, connect learners to other learners, teachers, educators, scholars and researchers, scientists and artists, industry leaders and politicians—in short, to any individual with access to the Internet who can enrich the learning process.

The organized use of Web resources and collaboration tools for curriculum appropriate purposes is called telecollaboration. Judi Harris defines telecollaboration as "an educational endeavor that involves people in different locations using Internet tools and resources to work together. Much educational telecollaboration is curriculum-based, teacher-designed, and teacher-coordinated. Most use e-mail to help participants communicate with each other. Many telecollaborative activities and projects have Web sites to support them".[14] The best telecollaborative projects are those that are fully integrated into the curriculum and not just extra-curricular activities, those in which technology use enables activities that would not have been possible without it, and those that empower students to become active, collaborative, creative, integrative, and evaluative learners.

[14] Harris, Judi,"First Steps in Telecollaboration"; available from http://ccwf.cc.utexas.edu/~jbharris/Virtual-Architecture/Articles/First-Steps.pdf; accessed 6 March 2002, p. 1.

3. Special educational needs of vulnerable users and the prevention of digital exclusion.

When we talk about users with special educational needs (SEN) we refer to a wide area of learners coming from different socio-cultural contexts and each having different characteristics and needs. Within this category we can identify: recently arrived foreigners who do not speak the language of the country correctly, students who have family problems of economic or social nature, students with developmental disorders, specific learning disorders and/or sensory disabilities.

Starting from the category above, students may have temporary or permanent educational needs and clearly it is impossible to take the same actions for all learners, but it is necessary to focus on the specific need in order to offer *ad-hoc* compensatory and supplemental tools and methods.

In this paragraph we present an overview on problematic and state of art solutions for vulnerable and special educational needs people.

3.1. Digital divide

Digital divide is defined as a "*division between people who have access and use of digital media and those who do not ".* By starting from this definition, we can already identify two main aspect of digital divide:

1. People having access to digital media;
2. People who can use digital media

Analyzing the first point, having access to digital content (for simplicity we consider the Internet as the gateway to all digital content) means having an Internet connection that allows you to surf and use all the services offered and now essential for productivity in the workplace and everyday activity such study and entertainment. Looking the data from the European broadband portal (Fig. 12 https://www.broadband-mapping.eu/) we infer how the efforts of recent years to bring broadband to the homes of European citizens has paid off, but still in many countries there are large areas where less than 10% of homes are served by an internet connection or have a bandwidth of less than 30 Mb/s. The availability of a stable 30 Mb/s connection is essential to take advantage of real-time services such as videoconferencing, screen sharing and video recording that have proven (especially in the COVID period) to be fundamental for Distance Learning.

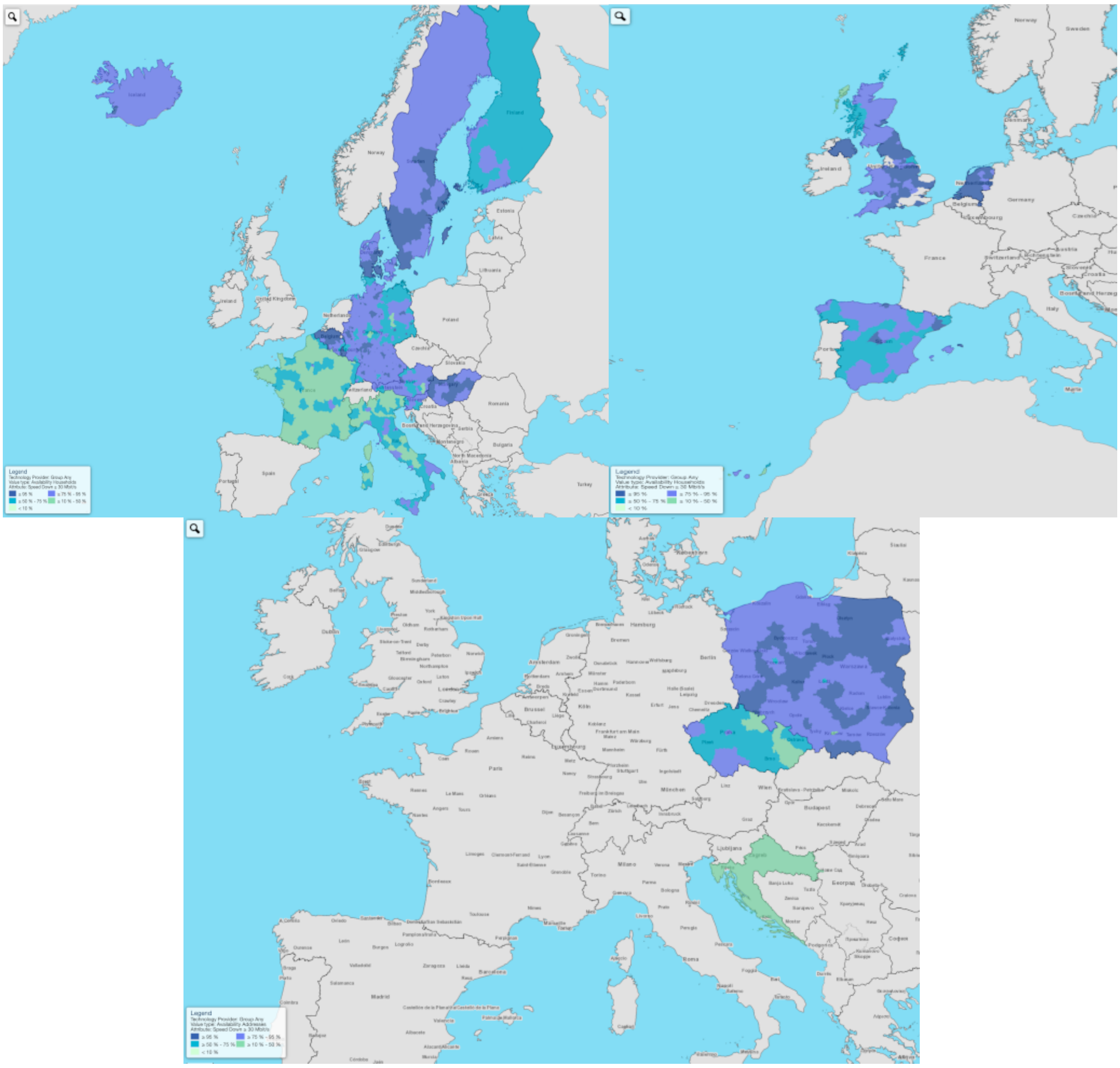

Fig 12. European Broadband Mapping (30Mbit/s map)

The second point refers to the possibility/ability of using digital media. This aspect is related both to problems of skills in the use of these technologies and so to digital literacy but it's also related to the accessibility of digital resources by people with disabilities (deaf, blind, dyslexic, etc.).

Specific disability is related to a specific accessibility challenge of digital resources. For example:

- Vision disabilities: blind people cannot use the monitor as an output device, visually impaired and color blind people can use monitors but they have great limitations either in the field of vision or in the perception of the messages they are intended to convey, messages that usually make use of colors.
- Hearing disabilities: deafness can vary depending on the severity (mild, moderate, severe and profound). Headphones or external amplifiers may be the solution for people who have a mild or moderate degree of deafness, while a higher level requires a different form of interaction other than sound and for video or audio conversation translation in sign language or a live subtitle generator.
- Mobility and Physical disabilities: physical impairment can vary from paralysis of limbs to limited mobility. There are many assistive technologies to help motor impaired people; the best input tool to use varies greatly based on the needs of the individual.
- Cognitive and learning disabilities: is a very large class of disability describing people that have a greater difficulty in cognitive tasks than average people. Cognitive disabilities include people with memory problems, attention problems, reading, linguistic and comprehension problems.

For each of these disabilities, since the 1980s, enormous efforts have been made to design and develop specific solutions that limit or sometimes even eliminate barriers and accessibility problems. These computer aids are called "assistive technologies" and correspond to technical solutions, both hardware and software, that allow the disabled person to overcome or reduce the conditions of disadvantage and to access information and services provided by computer systems.

Keyboards with big keys, braille screen/bars that translate screen text into braille alphabet (Fig.13), screen readers able to read the content of the screen and return it to the user vocally, screen magnifiers which act as "lenses" on the screen, are just an example of specifically hardware/software solutions designed for visual impaired people.

For these technologies to work to the best, applications, software or websites must follow standard rules designed to integrate these assistive technology.

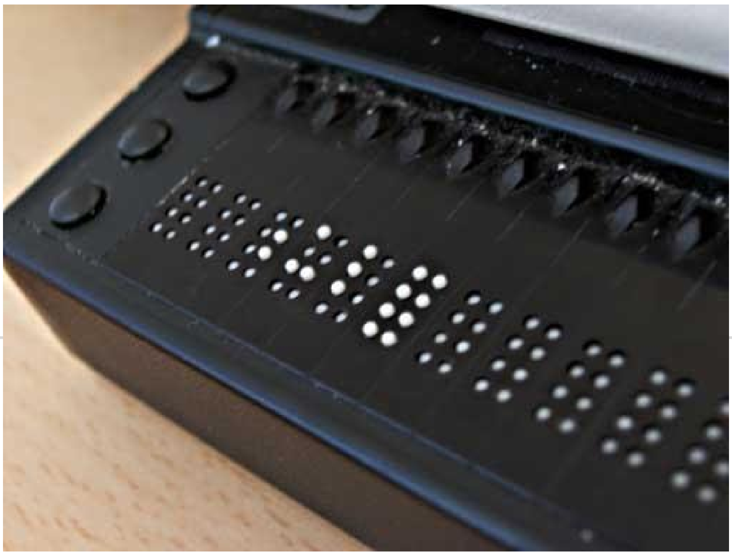

Fig 13. Braille screen (https://it.wikipedia.org/wiki/Schermo_braille)

In 1997, the World Wide Web Consortium (W3C) formed the Web Accessible Initiative (WAI), a working group with the objective of dealing with issues related to accessibility. The main guidelines proposed by WAI, which today represent a "*de facto standard*" for the Web, are:

- Web Content Accessibility Guideline (WCAG): guidelines for designing contents and structures of accessible Web sites;
- Authoring Tools Accessibility Guidelines (ATAG) guidelines that allow the developers of authoring tools to generate accessible content for the web;
- User Agent Accessibility Guidelines (UAAG) guidelines for developers of web browsers, multimedia web browsers, media players, and assistive technologies.

(https://www.w3.org/WAI/)

3.2. Virtual World and Virtual Reality for Special Educational Needs

Individuals with sensory disabilities face a deficit involving one or more senses such as sight, touch and hearing. As described in the preview section, technology can provide a compensatory and supplemental aid that can minimize this deficit and promote the building of cognitive skills and competencies.

People with sensory disabilities use their remaining senses to perceive the environment and compensate for the missing sense. A person who is blind, for example, develops more the sense of hearing, touch, and proprioception in order to orientate and navigate in the environment. 3D virtual worlds provide a customizable environment that can compensate sensory disabilities by manipulating visual, auditory, and tactile input and output.

Applications developed for individuals with disabilities, for example, can leverage the auditory channel as the primary output channel by integrating 3D sound technologies to aid orientation. In addition, the use of haptic devices allows manipulation of simple objects made for the 3D world and to receive haptic feedback in response; in Kreimeier J et al, you can find a systematic overview of main work and state of art research of use of virtual reality for blind and visually impaired people.

In 2007, a non-profit company called Virtual Ability (https://virtualbility.org) was formed with the aim to enable people, with a wide range of disabilities, to obtain an engaging gaming experience within virtual worlds. Virtual Ability has created a community of practice that offers a wide range of educational, social and entertainment opportunities (Fig.14).

Specifically, it has designed and developed "Lands" that can be visited using Open Simulator Virtual World and Second Life virtual worlds viewers, developed for people with disabilities or chronic illnesses. Thanks to an environment specifically developed to improve accessibility by people with disabilities, users can take advantage of an orientation service for the use of virtual worlds that can provide the scaffolding to exploit the full potential offered by such a tool in the educational and entertainment field.

Fig.15 VERVE virtual world
(https://ec.europa.eu/digital-single-market/en/news/virtual-reality-and-serious-games-improve-wellbeing-elderly-and-vulnerable-groups)

VERVE researchers examined the needs of older people and developed a series of intervention solutions based on serious games, virtual worlds and human and crowd simulations to mitigate the fear, apathy and social exclusion that often accompany a disability. In the context of the Verve project, Manera et al. developed a serious game called '*Kitchen and cooking*' that shows how real world activity simulated in a virtual world can be effective for the assessment and rehabilitation of older people with mild cognitive impairment.

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