



Serious Games in pre-K and K-6 education.

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Abstract- Serious Games indicate positive effects on pre-K and K-6 students and scaffold learning in a more engaging and motivating approach. Research has shown that Serious Games provide students with variety, the potential for widening participation, and the ability to work at their own pace. Serious Games based Learning has proven its added value in almost every aspect of the curriculum knowledge, skills, and attitudes, namely, Reading, Writing and Language learning, Geometric and Mathematical thinking, Strategic and Reasoning abilities, Critical thinking, Problem solving and Creativity, Executive Control skills, Physics, Geography and Science courses.

Keywords Serious Games, curriculum, knowledge, skills, motivation, game-based learning, interactive technologies

I. Introduction

Serious Games are identified as an emerging movement that improves learners' independence and meta-cognitive skills and helps instructors scaffold their learning and make it a more engaging and motivating activity. Digital games intrinsically implement well-known pedagogical approaches, namely behaviourist, cognitivist, and constructivist. The complex, open-ended, and collaborative nature of digital games reacts to players' actions in a highly realistic manner. The motivation to play games might be influenced by either highly strategic scenarios or simple games with a linear scenario. Digital games provide an additional way to enable students collaborate, communicate and understand topics that they might find too complicated to manage in a traditional class [1].

In line with two European 2020 key challenge strategies which were addressed to meet employment targets and take action to prevent social deprivation, unemployment, and poverty, four countries conducted a project called Code Red. Children at risk of exclusion co-developed serious games based on the characteristics and expectations of each group of the four partner countries, where delivering an educational message such as improving participation skills was more important than being a 'gamer'. Following the information and analysis of the actual stakeholders' needs, the participating countries co-designed a serious game methodology and implemented digital educational game prototypes to engage young people in an interactive (participatory) skills acquisition process. The Code Red project methodology proved to be a very enjoyable process for all participants, trainers, trainees and facilitators, creating a good grounding for the development of desktop and mobile games to act as an e-learning environment and increase accessibility [2].

According to the findings of a study conducted by Dr Sara de Freitas (2006), games and simulations are most effectively integrated into learning and teaching practice for constructivist rather than instructionist pedagogic approaches. According to the author, "the advantage of the 'serious games approaches' lie in their ability to create dedicated game content for learning purposes", despite the skepticism about its efficacy as a learning tool. Three main user groups, tutors of ICT skills, learners on ICT skills courses, and experts such as educationalists, game specialists, and developers, who were interviewed either from a distance or face to face workshop activities, were more engaged by games and simulations than by traditional text-

based approaches to learning. Their comments indicated that games give students variety and some fun, whilst reinforcing their learning, improve computer skills, provide learners with the ability to work at their own pace, and support visual/kinaesthetic learning. At the same time, the following key issues have arisen from the study: Increased motivation levels of learners, Potential for widening participation, Use of collaborative learning, and Efficacy of learning through experience. As for the improved motivation levels, one expert commented that even hard-to-reach disaffected young people are encouraged to re-engage with learning. The potential of games may widen the participation to learners with low literacy levels, due to language and writing skills, while they can be used flexibly in individual or group-based or combined situations to support collaborative learning. Furthermore, 78% of the respondents believe that attention spans can be improved when learning through experience and in an exploratory mode, where ‘drill and practice’ approaches are being used. The author concludes that the advantage of the ‘serious games’ approaches as learning tools lie in their ability to create dedicated game content for learning purposes, supporting exploratory learning in and between formal and informal contexts and supporting practitioners attempting to use them to engage and/or excite their learners [3].

Design of game formats in fields of advanced technologies such as Artificial Intelligence, Human-Computer Interaction, modeling and simulation, neuroscience and virtual reality might join effectively educational and entertainment goals, contextualizing the player’s experience in challenging, realistic environments, supporting situated cognition. SGs aim at improving learning processes that create positive situations among students and with teachers, where the player can gain knowledge through exploration and by practice possibly in collaboration with other people [4].

Experimental results of online web-based problem-solving activities show that these approaches highly motivate students and promote their involvement, concentration and enjoyment. Moreover, online educational games engage players in enjoyable activities that improve flow experience, promote learning achievements, and web-based learning interests toward immersive science learning and effective problem-solving activities. The competition and challenges of the online game reveal significantly higher learning interest and motivate students achieve better performance than those who learn with the traditional web-based learning approach. The results of the students’ flow experience indicate significant improvement of their attention to the activity regarding the four dimensions of flow experience that is: Firstly, flow antecedent indicates that the developed game provides clear goals, unambiguous feedback and a good sense of control. Secondly, flow experience implies that students are situated in an enjoyable and focused learning state and time seems to pass quickly. Thirdly, intrinsic motivation describes the intention or willingness of the students to engage with the web-based problem-solving activities. Lastly, extrinsic motivation which refers to students that achieved better performance due to the competition and challenges in the online game and revealed significantly higher learning interest than the traditional approach. Also, the online game approach is highly accepted by the students while the vast majority of them feel that it is helpful in improving their learning effectiveness [5].

II. Serious Games’ added value on Reading, Writing and Language learning

Designers’ and developers’ theories and designs have to be collaboratively created as long as a game is about both its internal design choices, such as its aesthetics, its storyline, and its characters and also about its play. Alice J. Robinson (2008), argues that video games can provide a framework for thinking about writing and the teaching of writing with the potential to make it fun. She states that the theory and practice of a play experience are a designed space with a strong analogy with the design of composition curricula and course syllabi, which has enormous implications for learning and literacy. Thus, it makes sense of our questions about



video games' significance as places for literacy to meet the needs of all and generate an interactive experience. In this view, designers and developers design documents and creative processes with principles surprisingly similar to the principles of creating any successful curriculum, especially in the area of written composition. Designers act as writers, creators, coders and players to meet the needs of all, knowing that play experiences are negotiated spaces and even more it has to be fun [6].

Although the classroom seems far removed from a virtual gamespace it can be extended beyond the confines of time and space. Computer gaming in the composition classroom can be enacted in a practical way to better teach writing in a pedagogy form of play that emphasizes active participation, leading to the production of rhetorical texts for a game space community. Gamers learn as they play, solving puzzles, learning strategies, becoming immersed in their writing while staying within the constraints of the game world and transforming the writing classroom from workspace to game space. Emergent game play pedagogy highlights play as an important part of the writing process, helping students creatively discover problems and rhetorical solutions within the game space, as they consider both academic and professional options for writing. This playful game space allows students to pursue their own discovery process and create their own challenging assignments [7].

As shown in a Serious Game research project (Mingoville universe platform), game-based material for language teaching and learning can be conceptualized through theoretical and methodological approaches associated with the educational design of games that generate theoretical concepts and practical methods for innovative product development. Sørensen and Meyer focus on the exploration and development of game based prototypes for language teaching and learning and produce credible knowledge about the benefits and outcomes of serious games. The serious game they developed is based on the idea that children learn and are motivated by problem solving and game activities, structured around themes and activities that cater children's desire to explore and play games. The missions aim at vocabulary training, spelling and word recognition as well as create narratives, draw pictures or sing karaoke in English, construct sentences and the most popular activity where children are interviewed by one of the course characters. Thus, the language is learned on a confident basis targeting at specific competences and curriculum goals with familiar objects from school and from the context of the home as well as games that are familiar to the children rather than traditional skills-based and text book based material focusing on reading, writing, spelling and listening. This paper describes a game-based concept for teaching languages in primary school that allows children to perform within their own categories of achievement and invite learners to participate in creating knowledge and performing expertise in protected linguistic environments, exploiting the 'fun-factor' of gaming [8].

In another paper, Meyer and Sørensen study the ways in which gaming is associated with 'serious' as well as 'pleasurable' learning that provide a framework to predict the benefits and learning outcomes of serious games locally as well as globally. The designers of the Mingoville platform suggest that narratives and intrinsic motivation are crucial factors in language learning and school activities such as reading, writing, listening and spelling communicating to parents, teachers and other potential users that gaming is not only 'fun' but also 'serious'. This research analysis of the Mingoville platform has shown that when games are used for language learning in the framework of a Computer Assisted Language Learning (CALL), children are motivated to learn languages as well as seamlessly integrate learning contexts and game narrative to create a complete learning situation. Thus, the game design must be intrinsically motivating; incorporating a fantasy theme that the target user is interested in and stimulates him through curiosity, which in Mingoville is incited through a number of mysteries or puzzles hinted at in the individual missions. Therefore, an important challenge involved in designing and conceptualizing serious games for language learning is that the "seriousness" of games can



support curriculum aims and goals such as the use of interactivity, collaboration and exploration based simulations for teaching English in primary school. On the other hand the theoretical framework is inspired by research fields such as educational design theory, game and play theory, informal learning, anthropological studies in children's cultures [9].

Advocates of computer games' integration in learning argue that games improve active participation of a new generation of learners in a way that traditional teaching does not. Game based strategies have been considered from educators, researchers, teachers and students as a perfect method to acquire motivation and engagement in language learning. Anyaegbu, Ting, and Li carried out a report integrating Serious Games in two Chinese primary schools to motivate the students in EFL (English as a Foreign Language) classrooms. The purpose of the study was to examine how a Serious Game platform would motivate, engage and arouse the interest of primary school students who are struggling to master EFL and identify the different factors that the platform affects the students' full motivation. Mingoville is an online English learning program, for children between 5 to 15 years old full of colored pictures, animated objects, sound, music and flash movies which attracts the young learners with mini-games and other entertainment activities. The games of the platform motivated the pupils to learn EFL in the following six categories: feeling fun and satisfaction, feeling autonomy and learn on their own, improving collaboration and cooperation, getting rewards and encouragement, fostering problem solving ability, appreciating learning environment. As a student commented "When I use Mingoville I feel calm, fun and willing to read more", " I learn fast and feel happy". The researchers concluded that the integration of Mingoville games in an EFL classroom, if properly organized, improves the Chinese students' classroom atmosphere, lowers students' anxiety, motivates and sustains their interest in learning ESL (English as a Second Language) and helps them learn and retain the language with new words, pronunciation, writing and listening, all in a fun way [10].

The potential of computer games in providing a language learning environment is investigated under the perspective of a virtual environment that supports language learning on its own (player-game interaction), as well as a tool or medium to facilitate collaborative learning (player-player interaction). Massively multiplayer online games (MMOGs) suggest a way of language use in games that actually encourage social interaction by enacting stories through collaborative tasks as well as chatting where the players are invited to construct sentences which are related to the virtual social setting in the game. Ang and Zaphiris (2008) wrote a research chapter in which they discussed and examined theoretical issues and practical challenges in game-based language learning to provide an overview of the natural learning process that happens within the educational game technologies of a CALL activity. This approach stresses meaningful interaction in authentic discourses and attempts to integrate learners in authentic environments in which computers are seen as artefacts that could mediate human interaction. The 'reader' is gradually learning to take meaningful actions and see the result of his decisions enacting his own stories instead of being a passive reader. The researchers believe that the increasing capability of graphic processing encourages the creation of player-game verbal interactions, which are closer to reality and related to the linguistic skills which the player must acquire to proceed in the game. Computer games might provide emphasis on the game-player interaction in which they are loaded with learning materials for learners to 'discover', congregate and engage in linguistic communication [11].

Griva Eleni, Klio Semoglou, and Athina Geladari (2010), conducted a pilot early Foreign Language (FL) project on a game-based context launched in two second grade primary school classrooms, in Greece. A topic-centered and activity-based approach was followed involving three basic levels: a practice level, an organization level and a production level. The games included outdoor physical games and constructions, such as sorting, ordering or arranging puzzles and labeling games. The activities raised the student's motivation, provided a context

for meaningful communication and involved students in a student-centered gaming, with the teachers as facilitators. Furthermore students expressed their willingness to be taught English in a game-based context, conceptualizing games as the ‘fun-factor’ of language learning [12].

III. Serious Games’ added value on Geometric and Mathematical thinking

GeoCAL, a multimedia software program based on Van Hiele’s geometric thinking level theory, was used in an experimental study to explore its learning effects on each geometric thinking level (recognition, visual association, description/analysis, and abstraction/relation) and overall geometric thinking. In the first stage, children engaged in sensorimotor activities; in the second stage, children dealt with problems of perspective; and in the third stage, children were able to recognise and discriminate location in two- or three-dimensional space. After the experimental treatment, the experimental group performed better than the control group in the post-test on geometric learning. The results demonstrated that although GeoCAL activities did not produce significant learning effects on recognition ability, they helped students develop a visual association’s ability to present illustrations of a variety of objects. In addition, provided interactive operating modes that enhanced students’ abilities to analyse and describe shapes and produced significant improvements in inference and induction abilities. GeoCAL proved its added value on the development of overall geometric concepts of second grade elementary school students creating problem-solving conditions to guide students in discovering issues and stimulating their geometric thinking [13].

The results of a mixed-method approach developed by the Center for Advanced Technologies of a school district engaged in learning from gameplay comprising a series of web-based games to reinforce academic standards for mathematics and facilitate elementary students’ cognitive math achievement and metacognitive awareness. In this case study, eight web-based mathematics games were developed using Macromedia Flash, targeting a variety of math skills, such as measurement, comparing whole numbers, solving simple equations, and mapping X and Y coordinates. After a five-week computer math drill game, the study findings indicated the development of positive attitudes toward math learning, even though it was more simplistic than commercial role-playing games in terms of visual, activity, and interaction design. The study results suggested that careful design of games for learning purpose depends on players’ real life physical surroundings and the players’ interactions with these surroundings, the dynamics of peer interaction, the active guidance of an instructor and the arrangement of physical classroom environment [14].

In another study, the researchers explored whether improving skills in the visual motor and working memory domains by gameplay, might enhance arithmetic performance and to what extent. Therefore, they compared the results of a math test, before and after game training, and that of traditional training by means of math paper exercises, whose contents were perfectly matched both in game training and traditional training. Evidence suggests that arithmetic performance enhancement induced by game play and paper exercises differs not only in terms of enjoyment but also in cognitive processes in the domains of visual motor skills and working memory. The results indicated higher accuracy percentages in the posttest than in the pretest session for the group that played the educational game, implying a stronger learning effect for the students who did the computer math test than for those who did the paper math drills. In addition, the results showed that describing the game versus math drills experience, a higher proportion of children selected the attribute ‘exciting’ for their game playing experience and, likewise, a higher proportion of the group that solved the paper math exercises selected the attributes ‘boring’ and ‘simple’. Game training compared with traditional methods elicited more positive affective responses, as long as children reported that playing the game was more enjoyable than many other activities when compared with traditional learning methods [15].

Drigas and Pappas (2015), in their review paper, examined the most representative studies over the last decade, which evaluate the effects of video games on mathematics achievement. They showed how video games support children's mathematic comprehension on fundamental concepts and improve their memory, attention and cognitive skills. They investigated the different types of online video games such as Educational Math Games, Adventure Games, Simulation Games and Mobile Video Games as well as Computer Video Games like Simulation Games, Strategy Games and Role-Playing Games presenting their positive effect on student's mathematical skills. Also, they presented both teachers' and students' perspectives about computer game-based learning in mathematics claiming that games motivated their interest, improved their creativity and could constitute auxiliary learning tools to build an innovative teaching model [16].

IV. Serious Games' added value on Strategic and Reasoning abilities

In a long-term pilot study, Bottino et al. M., Ferlino, L., Ott, M., and Tavella, M. (2007) performed a qualitative analysis of some of the cognitive processes involved in playing a number of computer games, mainly those usually called mind games. Although the findings are not generalisable, they offer insights underpinning basic strategic and reasoning skills, such as task comprehension of the objective to be attained and construction of a solution strategy to effectively use the available tools and their functional characteristics. The development of reasoning abilities originates from the ability to understand and manipulate the game's interface features, and the synergy between the learning process and the student's interaction with the software. Thus, computer games support cognitive processes in a way that is unavailable with traditional tools. The results showed that the proposed activities had a positive impact on pupils' logical and strategic reasoning skills, making them understand that working at random, even when playing, was not productive. Additionally, the empirical knowledge used when playing becomes a strategy affected by factors like attention, concentration and motivation [17].

Moreover, the results of another study suggested that constructing a game with an authentic, complex, and meaningful context might be a better way to enhance student motivation and deep learning than simply playing an existing game. This study investigated the effects of interactive computer-based learning tasks on students' intrinsic motivation and deep strategy use. In the construction condition, students were guided to master Dutch proverbs by constructing a 'drag and drop' game relating proverbs to pictures with the meaning of the proverbs. In the play condition, students were guided to master Dutch proverbs by playing a memory game, matching eight proverbs with their meanings as quickly as possible with minimal errors. The two different interactive tasks were compared with regard to students' intrinsic motivation and the use of deep learning strategies. The construction task might have been more authentic or meaningful than playing a game and invoking students' activities more. Additionally, constructing a game demands more student activity and stimulates a deep learning approach more than playing a game [18].

V. Serious Games' added value on Critical thinking, Problem solving and Creativity

MinecraftEdu is a highly effective and popular video game in which players build structures from materials obtained from the open landscape and focus on discovery and creativity. Setting strict playtime rules, basic or larger goals, and re-creating something from the real world encourages deep learning and allows players to learn the complex skills of coding and valuable life lessons. Using Minecraft to strengthen executive functioning in students not only can the curriculum be personalised but also helps every student to envision and build knowledge, demonstrating that Minecraft is an incredibly engaging video game [19].

The video game world has embraced the constructivist view of learning which considers the learner to be an active processor of information. The child gains mastery at different scaffolding levels while perceiving the impact and consequences of their actions and changing their knowledge representation to incorporate the experience. Modelling the construction of knowledge, reflecting the learner's thinking, formatting playing strategies, scaffolding children's thinking exploration, debriefing, and articulating knowledge with their peers are techniques that determine how constructivist a game could be. The extent to which games have adopted the constructivist approach to learning is a challenging process, especially because it refers to a child's period of cognitive development [20].

There are certain educational games that are not necessarily played only for pleasure, but are also about facts of life where children learn to think using a variety of epistemic frames and work in depth with and about complex problems. These games, named epistemic games, focus on children's expertise, professional-like skills, and innovative thinking rather than on their performance in basic and routine skills. Epistemic games can serve as excellent tools for reshaping education and training students to solve crises of innovation. By playing epistemic games, young children learn to see the world, solve problems in multiple ways, and step outside of what is usual. Epistemic games include eclectic features from both curricula: those that immerse children in rich learning activities and those that stress telling them what they need to know, not allowing much room to build expertise and innovation. Thus, they lead to expertise, professional-like skills, and innovative thinking that stresses immersion in practice and expands children's personal horizons beyond the norm [21].

Educational games were introduced as fuzzy expert systems with domain knowledge that captures an individual's problem-solving skills and establishes a rigid construct of intelligence. Problem solving orchestrates everyday cognitive, metacognitive, and behavioural situations, and constitutes a moderator for coordinating the competences needed in these cases. Immersive problem-based tasks, as well as individualised and cooperative learning experiences derived from the implementation of effective serious game techniques, develop preschool and primary school students' problem-solving abilities and academic achievement. Such competences include working memory, fluid reasoning, critical thinking, creativity, and time management [22].

VI. Serious Games' added value on students' Executive Control

Video Game Players employ executive control strategies much better than non-gamers to reduce the effects of distraction. Action Video Play fosters learning and brain plasticity, enhancing perception, attention and cognition across a wide variety of attentional capabilities, probing the limits of changes in learning. Improvements in attentional control of an individual's attentional capabilities are in fact the result of enhanced 'learning to learn' that the mechanism of game playing produces. Action Game Play enhances the abilities to allocate efficient attentional resources on a target and ignore distracting information, select relevant information over time and successfully track moving objects. Video Game Players change for the better their executive functions by sharpening their perceptual and attention skills and learning to perform tasks, ignoring other sources of potentially distracting information [23].

Results of a comparative experimental research demonstrate that professionals may achieve better results when using interactive technology systems to support children with different types of disabilities or problems than using the traditional non-technological methods. The qualitative findings of using a digital game rather than a physical one conclude with the following results: children seemed more concentrated using a digital game and obtained better therapeutic results. Characteristically, participants' attention was significantly better when they performed the Memory activity using the digital game than when they used the physical game. Also, the time the participants seemed distracted was significantly different in favor of the



digital use of the game, requiring less time to complete the activity and showing a significant lower number of interactions. Finally, the required time to complete the activity was less for the participants using the digital game condition. In general terms, it may be concluded children with special needs may achieve goals earlier and obtain better therapeutic results when using a digital game than when using traditional methods [24].

Studies support that computer-based interventions are most effective early on in the learning process, especially with novices. It is a question of special importance how to use technology to improve students' knowledge of cognition, regulation of cognition, monitoring their progress and motivation to scaffold their high-level thinking skills and self-regulate their learning. All the above are critical components as to how technology contributes to students' learning and metacognition and the extent to which computer-based support facilitates these skills. Self-regulation can be improved using technology-based supports which will be able to deliver short-term and longer-term interventions to improve cognitive skills [25].

The Annual Report No2 on innovation, conducted by the European Agency for Development in Special Needs Education 2013, presented approaches using serious games (accepted term for games with an educational intent) in three areas of activity in the Special Educational Needs network (SENnet): the integration of learners with special needs into mainstream schools, innovative learning environments and raising teacher awareness. In the first area of games to support learners with SENs and disabilities, the report confirms increased motivation, engagement and progression in a range of skills and abilities leading to increased independence, autonomy and resultant self-esteem. Finally, the report raises various issues that could be discussed including the inclusive opportunities provided by games in education, ethical issues in using some types of games and e-safety issues for young people with SEN who use online games [26].

In a study focusing on the relationship between the use of ICT and PISA test scores the addressed research examined firstly whether the type of use of ICT by students affects their school performance and secondly if this effect depends on students' social and economic background. It was found that ICT breadth of use tends to be positively associated with students' performance. Also, it was stressed that gaming when significant, is positively correlated with students' school performance, although PISA test scores are probably not the best way to measure the impact of gaming activities in the school curriculum [27].

González et al. (2007) introduced Sc@ut DS, a didactic game which was developed for learning communication concepts addressed to autistic children. The learning tool is an alternative and augmentative communicator developed by the research group GEDES of the University of Granada Nintendo DS, as hardware platform. Concepts are represented by pictograms, using videos and animations to make the learning process easier by imitation. The animations correlate the grammatical structure with the correspondent action in the real world. To enrich oral communication "Leoncio, The Lion" who is the mediator avatar in the learning process helps to obtain positive action assimilation. Games provide interesting human-computer interaction methods to improve communication level and the learning process in special education. Moreover, they can be seen as didactic tools that support pedagogic development and foster both motivation and attention levels to assimilate new concepts and increase interaction and social communication. Also, they can help students to enhance different abilities and examine their own limits in a self-regulated way. In conclusion, personalized design, according to the ideas of the personal world of each child improve better spatial, temporary and hand-view coordination ability, better concentration, motivation, attention and reasoning ability, and improve assimilation of strategies and social relationships, while children are happy playing and learning [28].

Extensive video game experience or pre-existing group differences between expert and non-gamer cognitive abilities resulted in differences in basic cognitive and perceptual performance,



as could be identified by an examination study of the game practice sessions between habitual gamers and non-gamers. Video game training compared to traditional training improve perceptual, attentional and cognitive abilities in an engaging and entertaining way, producing broad transfer to a number of tasks and encouraging participants to generalize the attentional control skills they learn in the gaming context to novel stimuli. Video game training appears to be one of the more interesting and promising mechanisms that improve task performance concerning executive control, attentional and cognitive abilities [29].

VII. Serious Games' added value on Physics, Geography and Science courses

Using a collaborative game-based learning approach, Sung and Hwang (2012) conducted an experiment in an elementary school natural science course to examine students' performance in a collaborative gaming environment. They developed a collaborative educational computer game integrating a grid-based mindtool to organise students' knowledge about what they have learned during the gaming process. Three classes of sixth graders from an elementary school constituted the experimental design (experimental group, control group A, and control group B) to evaluate the effectiveness of the proposed approach: differentiating a set of target plants for the subject unit "Identifying the plants of the school campus". The learning achievements of the experimental group students were significantly better than those of the students in control groups A and B, who learned with a conventional collaborative learning approach, and those who learned with an individual mindtool-assisted game-based learning approach. The experimental results indicated that the game-based learning approach improved the learning achievements of the experimental group students, improved their learning attitudes toward science, had a significant impact on improving the students' learning motivation in the natural science course, enhanced their self-efficacy in using computers to learn, and their confidence in learning collaboratively with their peers. Most of them also shared the feeling that the use of the shared repertory grid was helpful to them in exchanging information efficiently owing to the provision of the knowledge-organising and sharing facility embedded in the collaborative gaming environment. From the discourses of the students during the collaborative learning process, it is concluded that the more time students spend discussing and exchanging the information they have learned, the better their learning performance [30].

In a study of geography learning, researchers examined primary school students' achievement and motivation through an educational computer game. They designed and developed a three-dimensional educational computer game and found that it can be utilised in formal learning environments to support students in learning about geography. In the game-based learning environment, learning activities were presented with a storyline encompassing all goals, resulting in a fun learning experience. Their enjoyment was expressed through conversations with their peers and generated four affordances within the virtual game environment: exploration, interaction, collaboration, and presence. In relation to the qualitative results, players had high expectations of the game environment and played the game with great interest and enthusiasm. They became familiar with the shape of countries, places of interest in them, population and language of countries, and other cultural characteristics, indicating that this information could be helpful in their daily lives and exams. Regarding the quantitative results, it was found that students demonstrated statistically significantly higher intrinsic motivations and statistically significantly lower extrinsic motivations while participating in game-based activities. Finally, it was confirmed that computer games provide the characteristics of an authentic and relevant learning environment and increase learners' autonomy, fostering exploration, interaction, collaboration, and immersion in geography education while making learning fun. Significant learning outcomes were the result of the independent participation of students in game activities that anchored them in meaningful real-world events [31].



In a review of empirical studies on the use of serious games (SGs) in science education, a series of content analyses was conducted which identified the following research trends, among others: a surge of interest in the use of SGs in science education. Knowledge construction is the major learning goal for these SGs. SGs can be an effective and powerful tool for combining science learning with enjoyment. The coding scheme of the research framework consisted of three dimensions, namely game, pedagogy, and research method, which were used as lenses to obtain a complete picture of the advancements and trends in using SGs in science education from 2002 to 2013. SGs were categorised based on their gaming features as follows: adventure or role-playing games, simulation games, puzzle games, strategy games, action games, fighting games, or platforms. The pedagogical dimension was analysed in terms of the following aspects: subject domain, educational theoretical foundation, instructional strategy, and the pedagogical role of SGs. Finally, the research methodology was analysed in terms of the following aspects participants, research methods, and research foci. Dimensions, sub-dimensions, and categories of the coding scheme were generated by a grounded theory that employs social interactions and collaborative learning as crucial factors not only on participants' learning outcomes but also on relations among science educators, science instructors, and SGs designers. The number of empirical studies on the use of SGs in science education published from 2002 to 2013 implies that the potential of SGs in science education has evoked an increasing amount of research investigating the effectiveness of serious games in science learning. Most of the reviewed SG-relevant studies targeted elementary and junior high school students, mostly published in digital learning-related journals with the majority of the studies focusing on cognitive outcomes representing adventure or role-playing games as the most popular game type among the SGs used in the reviewed studies. As long as collaborative learning has always been highlighted in science education, one-third of the games used have a multi-player design. In this study, serious games are defined as a process of thinking and learning for educational purposes because what matters is the way in which the game is used and how it supports learning [32].

Daniel Short (2012) describes various key scientific and mathematical concepts that are able to be modelled in the classroom using a virtual world called Minecraft. Minecraft is a multiplayer sandbox video game (analogous to Lego construction sets) having a functioning ecology, with chemistry, biology, physics, geology, geography and mathematical aspects that are able to be modelled in the classroom to develop the scientific literacy of players. The construction of full lessons may take the form of single activities ranging from simple tutorials integrated into the normal classroom-based lesson to instructional units with beginning, middle, and ending scenarios. For example, in biology, in a minecraft map designed around the human body, students are immersed in a visual 3-dimensional environment to move and place blocks to mimic cellular activity. In the area of Ecology, the map generator of minecraft creates biomes and displays different heights, temperatures, humidities and foliage. In physics, the game simulates almost every real-life situation. In chemistry, which perhaps is not the strongest component of the game, students, with the help of their teachers, may experience a basic state of matter and phase change simulation (solid, liquid, gas) as well as explore a 3-dimensional periodic table of the elements. In mathematics and geometry, the game proposes the most obvious mathematical and geometrical concepts, such as the four operations and the generation of circles. Furthermore, it is possible to experiment with algebraic formulas and measurements of perimeter, area and 3-dimensional images. In geology and geography, the game generates cliffs, hills, mountains, ravines, and beaches next to oceans or lakes. The ability to configure a map using data imported from a geographical information system (GIS) makes it possible to model any location on Earth's surface. A Minecraft world can be a game-changer in the field of science instruction addressing the opportunity for collaborative lesson design between

instructors. The development of educational activity maps to be used as part of lesson plans is increasing not only for teachers but also for academic projects or proof-of-concept [33].

The implementation of teaching and learning methods based on simulations, virtual reality, and video games has been found to be one of the most effective methods for acquiring simple and complex concepts of physics from elementary school to university settings. Experiments can be conducted using technological features that cannot be performed in real laboratories. The role of teachers is significant as long as learners interact with each other and with their peers worldwide to achieve maximum learning and the best possible results that lead to a deeper understanding of learning [34].

VIII. Conclusions

Although digital games were associated with many negative stereotypes as for gamers' physical and mental health, there is a growing interest among teachers in using digital games in their lessons and learn how to use them as educational and motivational resources. The emerging movement identified as Serious Games aims to meet the needs of a new generation of learners that use digital devices frequently to communicate, express themselves, and understand the world around them. Serious Games use new gaming technologies for educational or training purposes thanks to game engines, middleware and Mods (modified versions of existing games). Digital games possess intrinsic learning qualities that challenge and foster pupils, who are pragmatically minded to learn by doing, learn from their peers and improve their skills. Digital games are based on the principle that playing is learning in a challenging environment where students can make mistakes and experiment with them, involving a process of trial and error. Although early educational software placed an emphasis on the behaviorist and cognitivist theories of learning, recent digital games encourage a constructivist approach, where players can readjust their knowledge and skills accordingly [1].

In order to determine if the game will make real life easier the teacher needs to identify aspects like: what is the background of the players, what are the learning goals, how does the game content relate to the learning goals, how integral is the content to the game mechanics, will the game engage the learners, how can the game be assessed, what retention rate will the game have; The challenges in embedding serious games into formal education lie in their ability to demonstrate the complexity and interconnectedness of issues. These challenges can be approached through the use of three frameworks, namely the identification of learning goals, identification of teaching enhancement and game assessment. In the area of pedagogy the learner needs to be active while playing rather than being cognitively overloaded. Game worlds need to be coherent and consistent and the learning objectives need to be understood by the player. Although there are barriers to using leisure and serious games as learning tools, such as the licensing costs and IT support, their potential to enhance and support learning will increase given the improving underlying technology, increasing interaction techniques, their engagement with pedagogy and teachers' confidence relating them to the curriculum goals in formal education [35].

The use of electronic games for education becomes a life-long process that can also take place outside the classroom. SGs provide learners' enjoyment, pleasure, motivation, ego gratification and emotion changing where, what and how they learn. Games facilitate immersion and active user involvement, whilst they need content and pedagogy expertise, design and impact research. Player motivation and engagement are critical to the success of the SGs, therefore, the game design is dependent on the learning objective, the intended user group and under what circumstances the game will be used. Overall, SGs might combine pleasure with education, involving interactivity, immersion and the level of pedagogy which is competent to support learning practice [36].

As a result of game ‘best practices’, a new design paradigm must be developed to meet players’ intended educational goals, ensuring an easier assessment and verification of educational effectiveness. Thus, there is a need for a well-established and appropriate implementation of instructional principles to provide a common ground for game designers and educators to collaborate and effectively incorporate games into the curricula. The game design must encompass all three learning domains: cognitive, affective and psychomotor, if content learning is to take place, as a result of increasing the efficacy of the medium and empowering students who are motivated by different means and learn differently [37].

As Prensky, M. states, the Games Generation, who grew up in the last quarter of the twentieth century, raise a number of important cognitive style for education, training and business in general, representing a break from the past and meeting many of the Game Generation’s changing learning needs and requirements: Twitch speed vs. conventional speed; Parallel processing vs. linear processing; Graphics first vs. Text first; Random access vs. step-by-step; Connected vs. standalone; Active vs. passive; Play vs. work; Payoff vs. patience; Fantasy vs. reality; Technology-as-friend vs. technology-as-foe, and ‘ Attitude’ which are almost totally ignored by education and training. One of the promises of Digital Game-Based-learning referring to trainers, teachers, content experts and game designers is that working together in small groups can create experiences that will radically improve the learning of millions of learners. Similarly, a school administrator or a teacher is possible to get learners of all ages totally involved in learning any subject matter, re-thinking much of what they believe about teaching and training, before they use these tools. As for a student or a trainee the days of sitting bored to tears in classrooms or in front of a boring computer are numbered [38], [39].

Games are becoming more pervasive and can be seen as a means for educating children and as metaphors for achieving behavioral and attitudinal changes providing a new paradigm for curriculum-based education. Learning outcomes have driven much of the conceptual work in the field and placed pedagogy at the center of the serious game design. The power of immersive experiences has the potential to change how we learn by creating immersive and distributed tutoring environments where personalized information when needed and adapted to the user’s requirements scaffold the process of learning. The researchers conclude that we are only just beginning to scrape the surface of the real capabilities that will exist in supporting serious games’ social learning long into the 21st Century involving all the stakeholders and centrally the learner [40].

Overall, it may be said, the interrelatedness of digital technologies in education domain is very dynamic and successful, facilitates and improves the educational approach via Mobiles [41-50], various ICTs applications [51-82], AI & STEM [83-94], and games [16], [95-99]. Additionally, the combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [22], [100-122] as well as with environmental factors and nutrition [123-126], accelerates and improves more over the educational practices and results.

IX. References

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