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MULTIPLE INTELLIGENCES AND ICT TOOLS (VIDEO GAMES/ 2D-3D SOFTWARES) FOR TEACHING CLIL TECHNICAL DRAWING

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RESUMEN

La enseñanza del dibujo técnico presenta ciertas dificultades para los estudiantes, como la comprensión de problemas visuo-espaciales y ciertos términos abstractos. Si sumamos el doble esfuerzo de aprender la materia en un segundo idioma, podemos encontrar estudiantes desmotivados.

En este trabajo de investigación teórico (revisión bibliográfica), partimos de la hipótesis de que el uso combinado de videojuegos y herramientas TIC (softwares 2D-3D) podría mejorar la comprensión de contenidos de dibujo técnico en estudiantes de secundaria (gracias a la estimulación y la mejora de la inteligencia visuo-espacial) y la adquisición de conocimientos de L2 (gracias a la mejora de las habilidades lingüísticas), además de aumentar su motivación por la asignatura.

Los resultados obtenidos tras el análisis de datos de los artículos seleccionados en diferentes bases de datos demostraron nuestra hipótesis inicial. Sin embargo, sería necesaria una investigación práctica para garantizar la efectividad de estos resultados teóricos.

ABSTRACT

The teaching of technical drawing presents certain difficulties for students like the understanding of visual-spatial issues and abstract terms. If we add the double effort of learning the subject in a second language, we can find discouraged students.

In this theoretical research work (literature review), we hypothesize that the combined use of video games and ICT tools (2D-3D software) could improve the understanding of technical drawing contents in high school students (thanks to the stimulation and improvement of visual-spatial intelligence) and L2 learning (thanks to the improvement of linguistic skills), in addition to increase their motivation for the subject.

The results obtained after the analysis of data from the selected articles in different databases demonstrated our initial hypothesis. However, a practical investigation would be necessary to guarantee the effectiveness of these theoretical results.

CONTENTS

INTRODUCTION

The teaching of technical drawing presents certain difficulties for students like the understanding of visual-spatial issues and abstract terms. If we add the double effort of learning the subject in a second language, we can find discouraged students.

For this reason, we consider that the combinated use of video games (VG) and 2D-3D softwares in the technical drawing classroom can be an effective alternative to motivate and teach students the use of technical drawing tools in a more friendly 2D-3D environment and easier to visualize, improving students visual intelligence. There are interesting experiences of integration of videogames in training contexts with different purposes: reinforcement of learning, digital literacy, simulation of social processes, promotion of experimentation and curiosity, etc. Video games can favor the development of multiple intelligences. Thus, visual-spatial intelligence can be improved thanks to the spatial orientation work required by the interpretation of 3D graphics, maps and spaces provided by these tools. Linguistic intelligence can be improved thanks to video games when users need to establish conversations with others or with the game itself, writing tasks or finding solutions based on given texts, etc. On the other hand, the use of 2D-3D softwares allows to create maps, planes o structures easier, faster and more comprehensible for students.

At the same time, this practice would improve the use of the L2[1] language in the different skills. Softwares are provided in English and present interfaces where communication between students and other users is possible both orally and in writing. CLIL[2] methodology can be similar to the use of video games, since in both

[1] L2 target language or second language.

[2] CLIL is the integrated learning of content and language. CLIL subjects, therefore, combine both learnings at the same time.

cases it is sought to improve the second language in an environment where communication and interaction occur naturally and with the use of new technologies.

1. METHODOLOGY

This theoretical research work aims to gather the maximum information published in books and scientific articles about three topics:

(1) What is the theory of Multiple Intelligences and what is its relation with the use of video games to promote certain types of intelligence for educational purposes.

(2) Experiences of video games in CLIL for the learning of L2 (the improvement of language is linked to the development of linguistic intelligence).

(3) Improved visual-spatial intelligence for the learning of technical drawing through video games and ICT[3] tools like 2D- 3D softwares.

We are interested in knowing how videogames and ICT tools would work in our educational area. Our hypothesis is that the application of videogames and ICT tools (2D-3D softwares) could improve the understanding of technical drawing contents in high school students (thanks to the stimulation and improvement of visual-spatial intelligence), while facilitating the acquisition of L2 knowledge (thanks to the stimulation and improvement of language skills or linguistic intelligence by using VG or ICT tools in the target language).

Given the scarcity of theoretical and practical studies that link these ideas, we intend with this work to collect information from them separately to be able to establish theoretical relations. This could be the starting point for a possible

[3] ICT is the abbreviation for "Information and Communications Technology".

implementation of a CLIL program where technical drawing is taught to high school students using ICT tools and VG. Until then, our mission is to establish a solid theoretical framework that supports a possible pilot study in the future.

Our work is divided into two sections. The first one is a theoretical framework where we gather information from texts (books and articles) of a theoretical nature on the topics of interest. The second part consists of a review of articles (quantitative and qualitative) extracted mainly from ERIC[4] database and Dialnet[5], which we have divided into three searches: (1) video games and L2, (2) video games and Multiple Intelligences and (3) 3D tools and drawing learning. The results obtained from this second part of our study, together with the theoretical framework will help us to find answers to our hypothesis and establish solid conclusions.

2. THEORETICAL FRAMEWORK

2.1. Theory of Multiple Intelligences

In the 1980s, psychologist Howard Gardner presented his Theory of Multiple Intelligences (MI). In it, he described that intelligence is a "set of skills, talents and abilities, called intelligences, which are independent from each other and potentially present in all people" (Gardner, 2013, in Garmen, Rodríguez, García-Redondo & Veledo, 2019: 2). This idea was a radical change with respect to what was seen as intelligence, as a single skill. Thanks to this new perspective, you can understand the differences in intelligences between people and how they can be improved with a more personalized education, since it is understood that each individual has different ways of learning based on their individual nature. This vision is applied in the new teaching methodologies and in the curricula of the schools more and more frequently

[4] ERIC is an online library where articles of education research are shared.

5 Dialnet is a portal for the dissemination of Hispanic scientific production specialized in human and social sciences. The portal is managed by the Dialnet Foundation of the University of La Rioja.

(Garmen, Rodríguez, García-Redondo & Veledo, 2019). This theory is committed to a student-centered teaching model, in which skills that globally involve the eight intelligences are developed: linguistic, logical-mathematical, visual-spatial, kinesthetic, musical, intrapersonal, interpersonal and naturalistic.

In MI Theory intelligences can be associated with an individual´s aptitude or potentials. The fact that an individual is either high or low in one specific area does not make him any more or less intelligent in the traditional sense (Šafranj & Zivlak, 2018). The eight intelligences proposed by Gardner are:

1. Verbal/linguistic intelligence: It is the ability to communicate through the processing of linguistic messages. (Moral Pérez, Fernández García & Guzmán Duque, 2015). People with this type of intelligence have an extensive vocabulary, are easy to learn languages and like to read books (Šafranj & Zivlak, 2018).
2. Logical/Mathematical intelligence: It is characterized by the ease to perform deductive and logic reasoning such as mental calculations, recognition of spatial relationships, size, distance or the understanding of spatial geometry (Moral Pérez, Fernández García & Guzmán Duque, 2015). People endowed with this intelligence are able to solve abstract problems through trial/ error, to recognize logical patterns that are also reproduced in nature. They are also good at reading comprehension exams (Šafranj & Zivlak, 2018).
3. Bodily-Kinaesthetic intelligence: It is the ability to skillfully manage the body and imitate movements of others, as well as to use the body sensitively to express emotions and ideas. People who have developed this type of intelligence have the ability to perform balance, coordination, flexibility, strength or endurance exercises (Moral Pérez, Fernández García & Guzmán Duque, 2015; Šafranj & Zivlak, 2018).
4. Musical intelligence: It is the ability to perceive, discriminate and express musical forms and sounds and to skillfully recognize and use rhythms, sound

tones and tonal patterns (Moral Pérez, Fernández García & Guzmán Duque, 2015; Šafranj & Zivlak, 2018). People who have developed this intelligence enjoy listening to music and playing instruments with ease, learn melodies and represent them mentally (Šafranj & Zivlak, 2018).

5. Interpersonal intelligence: It is the ability to empathize and understand other people (Moral Pérez, Fernández García and Guzmán Duque, 2015). People who have developed this intelligence are able to understand the feelings, motivations, emotions and needs of others, being able to use these skills for the benefit of others (helping them) or on their own (through manipulation or persuasion) (Šafranj & Zivlak, 2018).
6. Intrapersonal intelligence: It is the capacity for introspection and reflection that serve to achieve good self-esteem and self-concept (Moral Pérez, Fernández García & Gruzmán Duque, 2015; Šafranj & Zivlak, 2018). People with this kind of intelligence need to know themselves, reflecting on the emotions and feelings they harbor. They wonder about who they are or what the purpose of their lives is. (Šafranj & Zivlak, 2018).
7. Naturalistic intelligence: It "is the ability to recognise differences in nature, and classify both the animal and plant kingdoms" (Šafranj & Zivlak, 2018: 72). People who have developed this intelligence try to understand natural phenomena by observing and cataloging nature (Šafranj & Zivlak, 2018).
8. Visual/Spatial intelligence: Is "the ability to distinguish shapes- objects, to recognize the environment, to transform, interpret and express received perceptions (recognition of maps, orientation in virtual environments, etc.)" (Moral Pérez, Fernández García & Guzmán Duque, 2015: 249).

These intelligences are susceptible to qualitative improvement within a rich in stimuli cultural environment, from strategies and systematic activities. MI can be enhanced through specific activities, from different teaching practices supported in virtual environments to video games. In our current educational context these new forms of literacy, of communicative exchange and of thought are necessary to exploit

these novel digital instruments as powerful didactic resources in the classroom (Moral Pérez, Guzmán Duque, & Fernández García, 2014).

The determining factor in spatial intelligence is the ability to mentally visualize a 3D space regardless of the angle from which it is imagined, while maintaining the general structure in a logical and constant way. When we refer to spatial intelligence we speak of (Moral Pérez *et al.,* 2014):

- Ability to retain a visual scene and remember the details.
- Ability to recognize figures regardless of their spatial orientation, colour change, background.
- Ability to navigate in space, geographically.
- Understand the relationships that exist between the elements: proportions, shapes, colours.
- Know how to think in three dimensions.

People who have more developed this type of intelligence feel more comfortable drawing than writing and are more easily able to understand the shapes of objects, their colour, the action of light on them or the projection of shadows (Šafranj & Zivlak, 2018). They have facility for reading, writing, drawing, creating and understanding schemes, hieroglyphics or images, which are used as a form of visual-mental memorization. They also have the ability to orient themselves more easily in space or to understand maps. They especially enjoy watching videos and movies (Ibmian & Hadban, 2013; Šafranj & Zivlak, 2018).

Space intelligence can be improved with some training. There are games whose mechanics are directly related to the testing of spatial abilities and, by extension, spatial intelligence. Among the traditional games we could name, for example, Rubik's tangrams and cubes. On the other hand, some examples of video games that pose a special challenge for spatial intelligence could be Portal, Antichamber or QUBE, although classic platform games in three dimensions such as Super Mario Galaxy can also work well, since it is necessary to take into account the

position of the camera, the position of the character and the location, to correctly land in each jump.

2.2. ICT tools and VG in education and its application in CLIL

According to Casado Ahumada (2016), thanks to the use of ICT in schools, a new form of teaching-learning is being developed where video games have a very important role. The way in which these are used varies from video games created exclusively for the teaching of certain contents or skills to those not created for educational purposes that are used for the design of activities with which there are affinity relationships. They are educational instruments with a great potential in the learning process, especially in the acquisition of digital competences (since most children start in the digital world through electronic games) as well as of different facets of multidimensional intelligence. They can be applied to different areas and target various age ranges. In education it can be used the methodology of Game-based Learning in the teaching-learning process. It consists in the application of video games establishing educational objectives, using them as tools that support learning processes in a meaningful way. In secondary education, video games have been used to modify attitudes and behaviours, as well as to improve reading comprehension, among others (Moral Pérez *et al.*, 2014).

According to Dourda, Bratitsis, Griva and Papadopoulou (2014), the effectiveness of this tool is due to the fact that it encourages significant learning from real practice as well as encompassing learning in different areas by solving problems that combine diverse content. In this sense, its usefulness goes beyond learning contents until the development of specific skills, in addition to maintaining the motivation of the students to learn languages thanks to the adaptive possibilities of video games (Dourda, Bratitsis, Griva, & Papadopoulou, 2014). The integration of

content and language subjects as well as the incorporation of serious[6] videogames in the educational field has been some of the research tendencies occurring in the 2010s. The proposal of gamify content and CLIL could be used to support to the in-class sessions, with the videogame used like a workbook. This would increase exposure to both language and content in an entertaining way out of school and it would also provide further opportunities to practice. For example, games about the subject of history can be based on adventures as well as in strategy; whereas mathematics could be played with logic, ingenuity or puzzle activities, and physical education must focus on sports or related material. Once teaching and learning and playing purposes are defined, it is necessary to choose a videogame genre that can be suitable and adaptable to them (Casañ Pitarch, 2017). The motivational potential of video games can be multiplied when they are developed within the framework of the methodology of task-based learning and CLIL (Casado Ahumada, 2016). Sylvén & Sundqvist (2012) affirm that videogames provide a learning environment similar to that propitiated by the CLIL methodology, since they facilitate communication and interaction in the second language, promoting their learning. Playing such games conforms an emerging new learning. "What CLIL claims to do intramurally, that is, in the language classroom […] videogames do extramurally" (Sylvén & Sundqvist, 2012: 113).

Among the cognitive aspects generated by video games in users we can highlight (Aliciardi, De Cunto & Marcucci, 2016):

- Overcoming everyday reality: impossible things can be done in everyday life. We can enter into another reality, a different world with other rules.
- Exploration and experimentation: The player can use his skills to explore, know, experiment, solve, overcome obstacles, raise levels, learn from mistakes, etc.
- Acceptable difficulty and optimal frustration: Overcoming is progressive

6 Its design goes beyond pure fun and can be applied in different areas such as defense, education, scientific exploration, health, engineering, politics, etc.

and is achieved through challenges or tests that offer rewards, ensuring constant attention and motivation. The game represents a constant challenge to the player's self-esteem and perceptive, strategic and execution skills.

- Permanent challenge: The video game is available at any time and can be abandoned and retaken successively. This flexibility allows to expand its informal use in multiple moments and situations.
- Decision making: The player must constantly analyze the graphic environment and choose what action to take and when to do it.
- Safe reality: Students can enjoy the autonomy of unique experiences, solve problems, recreate conflicts, experience fears, rehearse solutions without the dangers of the real world.
- Loyalty and socialization: The user can participate in communities or forums related to the game, allowing their experience and information, as well as the written-communicative practice of a second language in a more relaxed environment.

2.2.1 Video games applied to CLIL L2 learning

The integration of content and language, as well as the incorporation of serious video games in education, has been some of the research trends of the last ten years (Casañ Pitarch, 2017). The effectiveness of video games is due to the fact that they provide an ideal context for meaningful learning where students must solve problems or give answers to certain questions that belong to diverse areas. With them, students can learn certain content and specific strategies. The proposal of gamify content and CLIL is used as a means of supporting classes, increasing the extramural exposure time not only to the language but also to the studied content in a more entertaining way. Casañ Pitarch (2017) proposes a model for the design of video games for the Gamification of Content and Language Integrated Learning (G-

CLIL) divided into four stages. It is presented as a circle covered by three different layers and four additional elements (see Figure 1) (Casañ Pitarch, 2017).

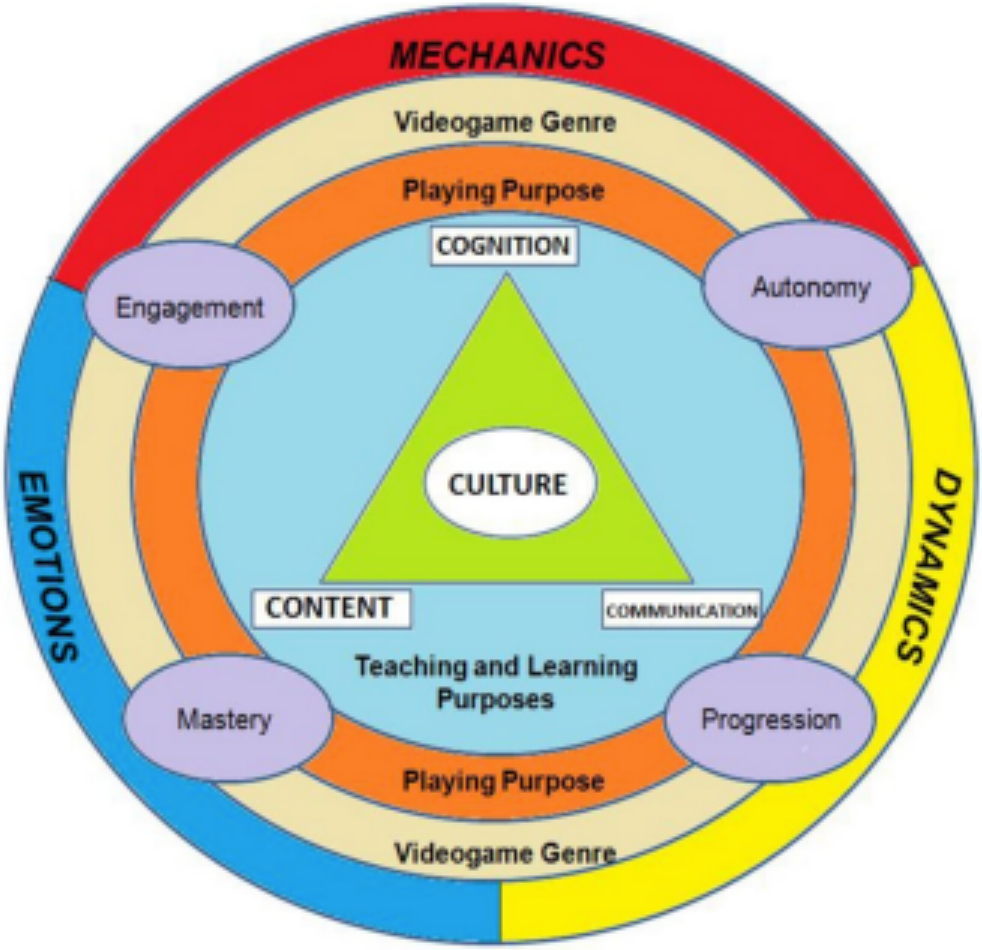

Figure 1. Gamification of content and language integrated learning (Casañ Pitarch, 2017: 111).

Stage 1: The analysis of the 4Cs[7] framework of Coyle, Hood & Marsh (2010) (content, communication, cognition and culture) should be extended with the aim of integrating its components in a videogame in relation with the learning purposes in

[7] According to Coyle (2007), the 4Cs Framework was developed to provide a theoretical basis for CLIL methodology and pedagogy from a holistic point of view, distinct from the traditional perspective of language teaching. This framework focuses on the "interrelation between content (subject), communication (language), cognition (learning and thinking) and culture (social awareness of oneself and otherness)" (Coyle, 2007: 550). Pay special attention to progressive cognitive learning, participatory and linked to cultural experience.

which educators plan and arrange the type of contents and the language they want to teach.

Stage 2: The analysis of how the content and language can be played, depending on the subject (math, history, music, or chemistry), applying suitable games to their needs.

Stage 3: To choose a videogame genre that can be suitable and adaptable to the subject and the students. It can be used the list provided by Adams (2013) divided in nine categories: “action, adventure, action-adventure, massive multiple-player online, role-playing, simulation, strategy, vehicle simulation and other miscellaneous genres” (Casañ Pitarch, 2017: 110).

Stage 4: To develop the videogame mechanics, dynamics and emotions in order to continue with the gamification process. It involves the development of the videogame itself: scenario, characters, goals, or awards, among others.

The following aspects should also be considered in order to achieve the success of the use of videogames for educational purposes in CLIL environments (Casañ Pitarch, 2017):

- Motivation by suitable learners’ progression along the videogame.
- Effective learning.
- Autonomy to learn how to manage and problems individually.
- Repetition to interiorize and master content and language forms.
- Create addiction by setting objectives, goals and rewards.
- Engage the students to continue playing “with storytelling, narrative and challenge […] that connect with the content” (Casañ Pitarch, 2017: 110) and the language that is targeted.

The motivational potential of videogames can be multiplied when they are developed within the framework of the methodology of task-based learning and CLIL (Casado Ahumada, 2016). Videogames resemble a CLIL learning environment,

facilitating the use of L2, encouraging interaction and communication among students, and can improve L2 competence, especially with respect to vocabulary. The intramural work (in the classroom) of CLIL seems to be developed in video games in an extramural way (Sylvén & Sundqvist, 2012).

Martínez & Schmitt (2010) believe that the process of teaching/ learning vocabulary can be facilitated with the use of technologies. Their study suggests "that the multimodality afforded by technology provides a way for the vocabulary learner to engage with language input in ways not possible with more paper-based media" (Martínez & Schmitt, 2010: 28)

2.3. Development of MI with ICT tools and videogames

Teaching should be based on learning by projects for the development of MI in virtual environments using ICT, making the process flexible, self-directed, structured and with specific goals prepared for the technological context of the classroom. Studies on the development of MI using videogames are scarce. There are interesting experiences of integration of videogames in training contexts with different purposes: reinforcement of learning, digital literacy, simulation of social processes, promotion of experimentation and curiosity, etc. (Moral Pérez *et al.,* 2014). Some cognitive aspects generated by video games among users are: Overcoming everyday reality in another reality, exploration, acceptable difficulty and optimal frustration, permanent challenge, decision making, safe reality without the dangers of the real world and loyalty and socialization (Aliciardi *et al*., 2016).

2.3.1. Chances provided by videogames to develop MI

The MI can be improved thanks to video games, but it is necessary to determine the type of activity, the mechanics of the game and the skills or abilities that want to be improved to activate the type or types of intelligence that interest us in each case

(Moral Pérez *et al.,* 2015; Aliciardi *et al.*, 2016).

1) Linguistic intelligence "can be activated with videogames involving skills related to description, narration, drawing-up of conclusions and summaries, conversations and all sorts of linguistic practices" (Moral Pérez *et al.,* 2015: 249). Activities to develop and implement different skills for this type of intelligence are:

- Sort words in sentences.

- Complete sentences with punctuation given a context.

- Alphabet soup with synonyms and antonyms.

- Tutti Frutti.

- Write fairy tales.

- To solve crosswords.

- Twisters and rhymes.

2) Logical-mathematical intelligence: Can be improved thanks to VG "that include mathematical puzzles, mental entertainment and calculation. A special mention needs to be made of successful experiences with grown-ups" (Moral Pérez *et al.,* 2015: 249) and subjects with special educational needs. Activities to develop and implement different skills for this type of intelligence are:

- Detective and clues.

- True and false from a story.

- Puzzle.

- Multiple choice of numerical results.

- Resolution of arithmetic problems.

3) Bodily-kinesthetic intelligence can be improved "by exergaming[8] (wiiU and XboxOne), simulating sports activities and improving motor skills" (Moral Pérez *et al.,*

[8] Exergaming is the practice of physical activity mediated by video games.

2015: 249). Activities to develop and implement different skills for this type of intelligence are:

- Directed movements.
- Concrete exercises of stretching, balance, proprioception coordination.
- Simulation of sports gestures.

4) Musical intelligence can be exercised through video games in which music is composed, instruments are played (following a melody, by means of key dialing, etc.), it is sung (as in *Singstar*), music is heard and the ear sharpens, Melodies are recognized or even danceable, in which case there would be a "simultaneous activation of kinesthetic body intelligence (as in *Step Mania* or *Dance Dance Revolution* VGs)" (Moral Pérez *et al.,* 2015: 250). Activities to develop and implement different skills for this type of intelligence are:

- Identify instrument sounds.
- Recording sounds with an instrument or microphone connected to the computer.
- Distinguish sounds in nature and select which objects are present.

5) Interpersonal intelligence activates “through social simulation games. Educational applications supported on prosocial games succeed in helping risk players, together with others which deal with ethical dilemmas and favor assertive relationships” (Moral Pérez *et al.,* 2015: 250). Aliciardi *et al.* (2016) mention some activities to develop and implement different skills for this type of intelligence, such as:

- Carry out group missions.
- Use of chat.
- Write queries to teachers.

6) Intrapersonal intelligence: It is improved thanks to social simulation video

games and role play in which "personal improvement and professional development are promoted through decision-making, negotiation, mediation, etc." (Moral Pérez *et al.,* 2015: 250). Activities proposed by Aliciardi *et al*. (2016) to develop and implement different skills for this type of intelligence could be:

- Success of negotiation.
- Awards for good behaviour.
- Positive phrases to improve self-esteem.

7) Naturalistic intelligence can be improved thanks to video games in which experimentation activities are carried out "like *Norrath* or Spore, creating new species" (Moral Pérez *et al.,* 2015: 250). Aliciardi, *et al.* (2016) indicate some activities to develop and implement different skills for this type of intelligence:

- Recognition of similarities and differences between the artificial and natural world.
- Differentiation of aquatic and terrestrial ecosystems.
- Recognition of natural and artificial objects (through classifications and added tags).

8) Visual-spatial intelligence can be improved with video games that require the interpretation, ideation or construction of maps, puzzles or virtual space environments in different dimensions and in which different types of views or perspectives are used. For example, The Sims[9] Sims is a video game that favors the activation of this intelligence by including, among its activities, the construction of buildings and the environment of a virtual city (Moral Pérez *et al*., 2015). These and other examples can improve spatial abilities with positive cognitive effects related to memory.

Abilities of spatial orientation are: (1) ability to determine

[9] The Sims is a well-known video game where real life is recreated and the player can create virtual characters, build their homes, workspaces, grant them feelings, interact with other virtual characters, etc.

> relationships between different spatial objects, (2) ability to recognize the identity of an object when it is seen from different angles, or when the object is moved, (3) ability to consider spatial relations where the body orientation of the observer is essential, (4) ability to perceive spatial patterns and to compare them with each other, (5) ability to remain unconfused by the varying orientations in which a spatial object may be presented and (6) ability to perceive spatial patterns or to maintain orientation with respect to objects in space (Gutierrez, 1996: 9).

Activities to develop and implement different skills for this type of intelligence are:

- Paint images.
- Drawing, make a copy of an image.
- Make a sketch of a house, map or terrain.
- Construction of cities, interior of houses.
- Tangram.

The improvement of different types of MI or of all in general, can be achieved by selecting the type of video game to be used for educational purposes. In order to train all intelligences, systematic activities are recommended with the capacity to produce appropriate interrelationships among them, promoting collaborative work (Moral Pérez *et al.,* 2015).

2.4. Visual intelligence in the subject of Technical Drawing

As studied above, visual intelligence is the ability to think in images, including imagination, spatial orientation and dexterity to represent reality graphically. Is the capacity “to perceive the visual-spatial world accurately and to perform transformation on one's initial perceptions” (Morgan, 1996: 267). It allows us to differentiate shapes and objects, distinguish and manage the idea of space,

elaborate and use maps, templates and other forms of representation, identify and situate oneself in the visual world, transform perceptions, imagine a movement, a scene, visualize images mentally. Painters, sculptors, architects, inventors, navigators, geographers are some of those who best express this ability (Sullivan *et al.*, 2011; Šafranj & Zivlak, 2018).

In what concerns our teaching work in technical drawing subjects in Secondary level, there is a very close relationship with the previous definition of visual-spatial intelligence, a link that is translated into the constant realization of plastic handmade exercises. We provoke the visual-spatial intelligence around the image when we exercise the analysis of the meanings of the works of art and we try to understand and perceive the message of an image. Perceiving the relationships between the objects and the forms that make up the visual message depends on the experiences of the students and on the environment in which learning happens. Developing their perception and perceiving complex relationships are aspects that the technical drawing teachers work on and have as a constant challenge.

3. LITERATURE REVIEW

3.1. Data selection

A bibliographic search was carried out in the main databases of social sciences and education, based on four pillars: videogames, 2D-3D software, the theory of Multiple Intelligences and the introduction of the three previous ones in an educational context for the teaching of CLIL technical drawing.

The search methodology used was: qualitative or quantitative research studies carried out in the last 10 years (for search 1 and 2) and without time limit (for search 3), published in scientific journals and indexed in different databases as ERIC and Dialnet. Sistematic reviews or meta-analysis were excluded. Reverse search studies

have also been included from the authors of the selected studies. We have selected accessible full text articles and discarded articles that have not been found in full text. The key words used for searching were:

Search 1: Video games and Multiple Intelligences.

Search 2: Video games and L2.

Search 3: 3D tools and drawing learning.

3.2. Data analysis and results

The following sections detail the analysis of data and results in each of the three searches indicated above.

3.2.1. Search 1: Video games and Multiple Intelligences

Using the keywords "Video games and Multiple Intelligences" and the descriptors cited above, we found 12 results. Of them, we selected 10 articles after reading the abstract. After the complete reading, 6 articles were finally selected for our study. Below we describe the results found and provide a table (see table 1) that synthesize and facilitate their understanding. We can find the whole data related to these studies in a table in Annex I.

Most of the selected studies have Spanish or US origin and have been published in the last 5 years. 3 studies used a quantitative methodology (Garmen *et al.,* 2019, Moral *et al*., 2018 and Cutumisu, Chin & Schwartz, 2014), 1 study used qualitative methodology (Lovin, 2018) and 2 studies combined qualitative and quantitative methodology (Sajjadi, Vlieghe & de Troyer, 2017 and Moral Pérez *et al*., 2015). The total number of participants of all the studies were 1149, being of different educative levels: 592 participants of primary, 249 of secondary, 237 university participants and 308 participants of different ages and educational levels mixed in the

corresponding study. The videogames that were studied in these works were:

- TOI "(Tree of Intelligences) is a digital tool to evaluate multiple intelligences and to perform interventions through video games" (Garmen *et al.*, 2019: 95).
- Various videogames available online (Sajjadi et al., 2017) on educational databases (del Moral *et al.*, 2018).
- Digital Math gaming (Lovin, 2018).
- Naraba World is a serious video game aimed at students of early childhood and primary education (from 4 to 8 years old). The children create their own avatar to explore and learn in the different passages, where they can also fly different transports and live 3D adventures (del Moral Pérez *et al.,* 2015).
- Posterlet is a serious VG created "to assess students' choices to seek negative feedback and to revise, in which students learn graphical design principles while creating posters" (Cutumisu *et al.,* 2014: 17).

All these games are specific for educational context, which it is known as serious games. Some of the subjects where they were applied were mathematics, knowledge of the medium, music or graphic design.

5 of the 6 studies found that the application of these video games improved some of the 8 MI. 4 studies concluded with improvements in all MI that were studied (Garmen *et al.,* 2019; del Moral Pérez *et al.*, 2018; Lovin, 2018 and Cutumisu *et al.,* 2014) and 1 of them reported improvements in 3 of the 8 MI studied (Moral Pérez *et al*., 2015). Sajjadi *et al.* (2017) studied the relationship between participants' IMs and their game preferences, establishing relation between them that are not exclusively related to gender. They also affirm that "evidence-based mappings between game mechanics[10] and the different MI dimensions exist, which can facilitate the use of the MI theory for player- centred game design" (Sajjadi *et al.*, 2017: 332). We provide one of these mappings related to visual-spatial intelligence in figure 2.

[10] The use of abstract objects (modes and purposes) and their relationships in videogames are regulated by rules, which organize a set of ludic activities and turn it into a complete and coherent game. Some of them are known as "game mechanics" (Fabricatore, 2007).

		Method				Educational level						Results/ improvements										
												Multiple Intelligences										
	Country	Qualitative	Quantitative	Number participants	Study duration	Primary	Secondary	University	Other/ Mixed aged	Videogame	Subject application	L	LM	BK	M	I	IT	N	VE	Motivation	Subject contents	Others
Garmen et al. (2019)	Spain		•	372	1 y	•				TOI		+	+	+	+	+	+	+	+			
Moral Pérez *et al.* (2018)	Spain		•	119	8 m	•				Educational VGs		+	+					+				
Lovin (2018)	USA	•		12	/		•			Digital Math Gaming	Maths		+							+		
Sajjadi et al. (2017)	Belgium	•	•	308	/				•	Multiple VGs												•
Del Moral Pérez *et al.* (2015)	Spain/ Colombia	•	•	101	1 y	•				Naraba World	Matts Environment Knowledge Music	•	+	+	•	•	•	•	+			
Cutumisu *et al.* (2014)	USA		•	237	1 s		•	•		Posterlet	Graphic design								+		+	

Study duration abbreviations: y (year), m(month), w (week), s (session)

MI abbreviations: L (linguistic), LM (logical-mathematical), BK (bodily-kinesthetic), M (musical), I (Interpersonal), IT (Intrapersonal), N (Naturalistic), VE (Visual- spatial)/ Studied (•), Statistically significant improvement (+).

Table 1. Data extraction. Video games and multiple intelligences.

Lovin (2018) also studied the motivation of students to learn mathematics through videogames, finding a significant increase in it. Cutumisu *et al.* (2014) also reported improvements in the learning of videogame content related to graphic design in high school and university students.

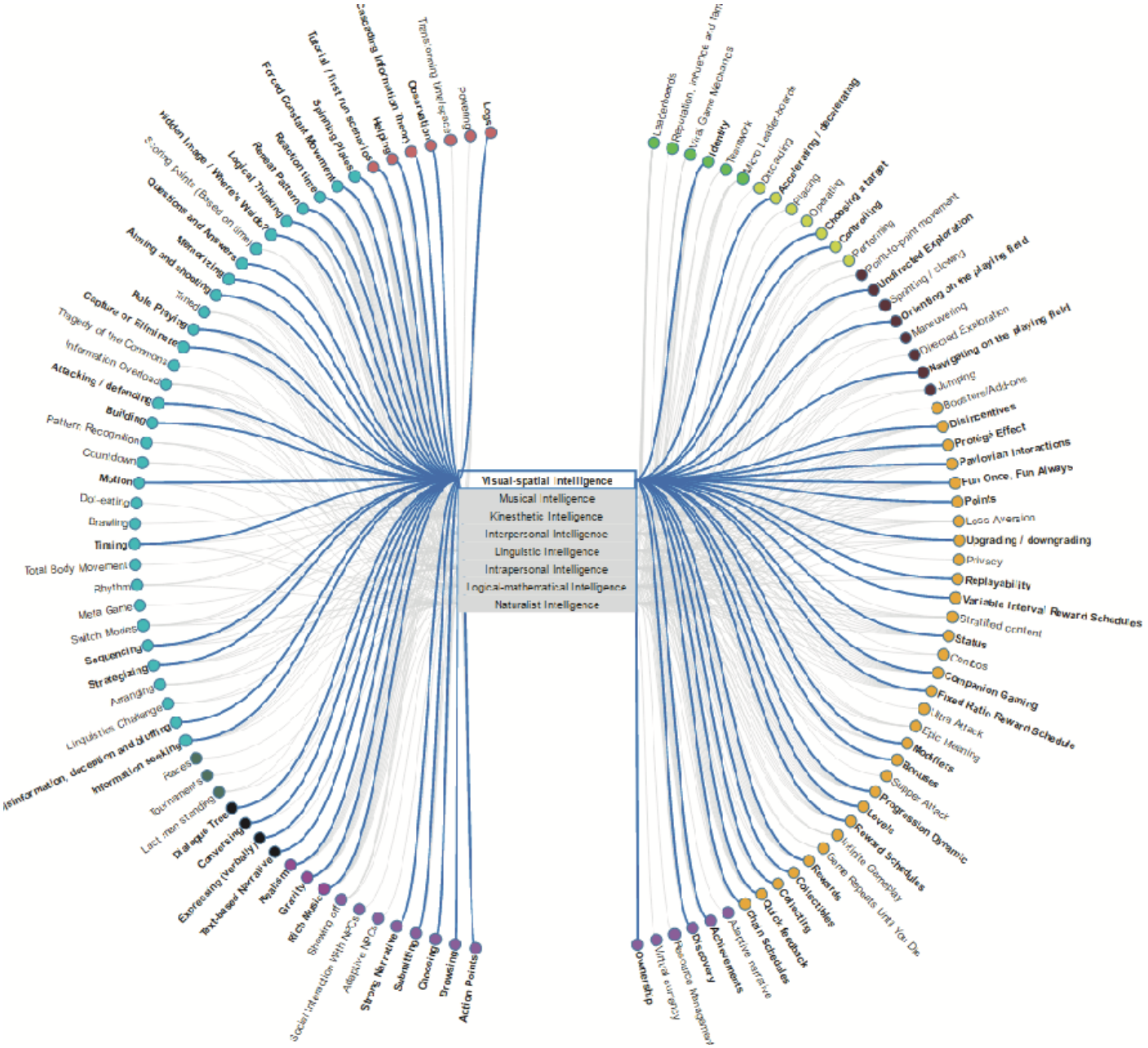

Fig 2. Visualization of all MI dimensions and game mechanics (Sajjadi, 2017: 331)

3.2.2. Search 2: Video games and L2

Using the keywords "Video games and L2" and the descriptors cited above, we found 24 results. Of them, we selected 14 articles after reading the abstract. After the complete reading, 13 articles were finally selected for our study. Below we describe the results found and provide a table (see table 2) that synthesize and facilitate their understanding. We can find the whole data related to these studies in a table in Annex II.

The studies analyzed in this second search have different origins: 7 from the USA, 1 from Finland, 1 from Iceland, 1 from Spain, 1 from Canada, 1 from China and 1 from Greece.

In relation to the methodology used, 4 studies were qualitative (Howard & Do, 2017; Enticknap-Seppänen, 2017; Ibrahim, 2016 and Cardoso, Grimshaw & Waddington, 2015), 1 quantitative (Calvo-Ferrer, 2015), 3 used qualitative and quantitative methods (Vosburg, 2017; Cerezo, Caras & Leow, 2016 and Vosburg, 2015) and 4 used mixed method (Bédi *et al.,* 2016; Hitosugi, Schmidt & Hayashi, 2014; Neville, 2014 and Chik, 2014).

The total number of participants adding all the studies was 309. Of these, 51 participants were primary school students, 248 were university students and 10 of different ages and educational levels.

The mother tongue (L1) of the participants was: English (133 total participants in 6 different studies), Korean (34 participants), Finnish (40), Spanish (65), Chinese (14 total participants in 2 different studies), Greek (17) and mixed nationalities (6). The most studied target language (L2) was English (in 7 studies, applied to a total of 153 participants), followed by German (in 3 studies, applied to a total of 36 participants), Spanish (1 study, 70 participants), Japanese (1 study, 20 participants), Egyptian (1 study, 7 participants) and Icelandic (1 study, 6 participants).

The video games applied in the studies were:

- *"Quest Atlantis* is a digital game built via the Active Worlds immersive virtual environment to create learning opportunities for children aged 9-12" (Howard and Do, 2017: 22.) It is an educational serious game.
- *Go Animate* is an online animation software, used to create a VG for this study. In this VG, the tour guide has an inappropriate behavior towards clients in 7 different situations in which students must interact: "meet with the tourist group, explain the itinerary, safety procedures, recommend places to eat, describe monuments and deal with an emergency" (Enticknap-Seppänen, 2017: 106). It can be considered as an educational serious game.
- *World of Warcraft* (2 studios) is a massive online multiplayer role-playing videogame that offers a virtual world in which players generate characters that interact with other players in the online gaming environment via an avatar. It is not an educational serious game.
- *Virtual Reykjavik* is a VG in which "learners interact with virtual characters […] to practice speaking and listening skills, to learn about the language and culture by solving various tasks" (Bédi *et al.,* 2016: 37). It is an educational serious game.
- *The Gustar Maze* video game is used to guide "induction to gradually promote deeper processing of the target language structures" (Cerezo *et al.,* 2016: 274) (Spanish *gustar* verb in this concrete study). It is an educational serious game.
- *Baalty* is a serious VG for educational purposes "to teach entrepreneurship skills and business ethics to Egyptian students by simulating the process of managing a retail store in Upper Egypt" (Ibrahim, 2016: 70).
- *The Conference Interpreter* is a free serious VG designed for educational purposes to "teach L2 specialised vocabulary both without the aid of instructional support and more efficiently than traditional education" (Calvo-Ferrer, 2015: 12).

Author (year)	Country	Method			Number of participants	Study duration	Educational level				Videogame	L1 language	L2 language	Results/ Improvements									
		Qualitative	Quantitative	Mixed			Primary	Secondary	University	Other/ Mixed aged				Language skills						Subject contents	Motivation	Expectations of learning engagement	Enjoyment	Learning autonomy
														V	G	R	C	W	GL					
Howard & Do (2017)	USA	•			34	5 s	•				*Quest Atlantis*	Korean	English				•[11]							
Enticknap-Seppänen (2017)	Finland	•			40	4 s			•		*Go Animate*	Finish	English									-		
Vosburg (2017)	USA	•	•		7	8 w			•		*World of Warcraft*	English	German								-			
Bédi *et al.* (2016)	Iceland			•	6	13 w				•	*Virtual Reykjavik*	Various	Icelandic				+			+[12]				
Cerezo *et al.* (2016)	USA	•	•		70	10 w			•		*The Gustar Maze*	English	Spanish		+			+						
Ibrahim (2016)	USA	•			7	4w+ 4s			•		*Baalty*	English	Egyptian						+					
Calvo-Ferrer (2015)	Spain		•		65	5 d			•		*The Conference Interpreter*	Spain	English	+[13]							+	+	+	
Cardoso *et al.* (2015)	Canada	•			4	4 w				?	*Spaceteam*	Chinese	English				+				+		+	
Vosburg (2015)	USA	•	•		7	8 w			•		*World of Warcraft*	English	German		+			+						
Hitosugi et al. (2014)	USA			•	20	1 s			•		*Food Force*	English	Japanese	+									+	
Neville (2014)	USA			•	22	6 m			•		Custom-built *3D-DGBLL environment*	English	German	+	•					+[14]				
Chik (2014)	China			•	10	12 m			•		Various VD	Chinese	English						•					•
Dourda *et al.* (2014)	Greece		•		17	8 w	•				*Whodunit*	Greek	English	+		+		-		+[15]				

Study duration abbreviations: y (year), m (month), w (week), s (session).
Language skills abbreviations: V (vocabulary), G (grammar), R (reading), C (conversation/ communication= speaking/ listening/ reading), W (writing), GL (general L2 learning).
Studied (•), Statistically significant improvement (+), not improvement (-).

Table 2. Data extraction. Video games and L2 learning.

[11] The use of politeness in linguistic interactions.
[12] Cultural content.
[13] Control group (content without VG) had same learning results as experimental group (same content with VG).
[14] German recycling and waste management practices.
[15] Activities on geography in virtual real context.

- *Spaceteam* (only level 1 studied) is a mobile video game as a classroom tool created to develop “oral fluency, and to examine students and teacher perceptions of the game” (*Cardoso et al.,* 2015: 103). An inter-player oral communication of the team is established, which must be fluid, fast and intelligible, for the successful piloting of a spaceship (*Cardoso et al.,* 2015). It is an educational serious game.
- *Food Force* is an UN-sponsored off-the-shelf videogame “to raise the awareness of school children and adults about world hunger” (Hitosugi *et al.,* 2014: 23). It is a serious game used for educational purposes.
- *Custom-built 3D- DGBLL environment:* It is a “custom-built 3D-DGBLL environment, employing a first-person player interface to teach German recycling and waste management practices within the grammar context of two-way prepositions”. The video game was created to teach these particular contents, which favored greater "curricular integration [...], the development of more effective workflow patterns and gave a more detailed examination of the possibilities and limitations of these environments” (Neville, 2014: 26). It is an educational serious game.
- *Various VG* whose participants used to play. It is not a serious game.
- *Whodunit “(Who done [did] it?)* is a [...] plot-driven, web-based detective game” (Dourda *et al*., 2014: 247) that uses geography, “utilizing QR Codes and Google Earth, for teaching English Language to [...] Primary School students” (Dourda *et al*., 2014: 243). It is an educational serious game.

Of the 12 different VG that were used in the 13 studies, 10 were serious games and 9 were VG created specifically for educational purposes. Vosburg (2017), Vosburg (2015) and Chik (2014) did not use serious games in their studies. Vosburg (2017) and Chik (2014) reported no improvements in L2 learning with the use of these VG. However, Vosburg (2015) affirmed that World of Warcraft improved grammar and writing skills of its participants. Of the 10 studies that used serious games, 9 measured different language skills and 8 reported improvements in some

or all of the measured (depending on the study).

11 of the 13 studies measured different language skills in the participants. For our analysis we have divided them into 6 items (vocabulary, grammar, reading conversation/ communication, writing and general L2 learning). 8 studies made a pre-post intervention comparison to determine the possible improvements of the participants in different areas (Bédi *et al.*, 2016, Cerezo *et al.,* 2016, Ibrahim, 2016, Cardoso *et al.,* 2015, Vosburg, 2015; Hitosugi *et al.,* 2014; Neville, 2014 and Dourda *et al.*, 2014). 6 studies reported improvements in all measured skills (Bédi *et al.*, 2016, Cerezo *et al.*, 2016, Ibrahim, 2016, Cardoso *et al.*, 2015, Vosburg, 2015, Hitosugi *et al.*, 2014), 1 study reported improvements in 1 of the 2 skills measured (Neville, 2014) and 1 study reported improvements in 2 of 3 measured skills (Dourda *et al.*, 2014).

1 study (Calvo-Ferrer, 2015) compared the language skills between an experimental group (content VG learning) and a control group (same content without VG learning) pre- post interventions. They reported improvements in vocabulary learning in both groups, so they determined that the application of VG did not increase the learning of that skill over the teaching of the same content without VG. However, the students of the experimental group perceived that this form of teaching were more enjoying and motivating. Likewise, their expectations of learning commitment were greater than in the control group.

In total, 4 studies reported improvements in vocabulary learning thanks to the intervention with VG, 2 studies reported improvements in grammar, 1 study found improvement in reading skill, 2 studies indicated improvements in communication of participants, 2 studies found improvements in writing skill and 1 study found improvements in the overall learning of L2. Therefore, there was a general improvement of 75% in the language skills measured in the different studies after the intervention.

3 of the 13 studies measured, in addition to the language skills, the learning of different contents in L2 (such as cultural topics, recycling and waste management practices or geography) and found improvements in their learning after the implementation of the program with VG (Bédi *et al.*, 2016; Neville, 2014 and Dourda *et al.*, 2014).

2 out of 3 studies that measured the motivation of the participants indicated that the use of VG increased their motivation for learning L2 (Calvo-Ferrer, 2015 y Cardoso *et al.,* 2015). However, a third study indicated the contrary (Vosburg, 2017). The reason was that gaming provides a viable language learning option for many students, but something as simple as group membership (in group gaming) can severely hinder the possibilities of language learning and motivation at an individual level. The lack of motivation of one or more participants in a group videogame can negatively affect the rest of the participants, with its consequent secondary demotivation.

Enjoyment was measured in Calvo-Ferrer (2015), Cardoso *et al*. (2015) and Hitosugi *et al*. (2014). All these authors stated that the participants enjoyed the L2 learning experience through VG.

3.2.3. Search 3: 3D tools and drawing learning

Using the keywords "3D tools and drawing learning" and the descriptors cited above, we found 17 results. Of them, we selected 6 articles after reading the abstract. After the complete reading, 6 more articles were added after reverse search. After the complete reading, 8 articles were finally selected for our study. Research studies were included without limitation of publication date given the scarcity of them in this field. We can find the whole data related to these studies in a table in Annex III.

Before beginning with the analysis of the obtained data, we must make a clarification. None of the studies analyzed in this section deals directly with technical

drawing, but mainly with the use of different ICT tools for the study of geometry in subjects such as mathematics. It is important to understand that geometry is the theoretical basis of descriptive geometry or technical drawing. When we make a technical drawing, we apply calculations and measurements to represent objects or practical ideas on a flat surface, which are based on the theoretical concepts of geometry and the use of instruments whose origin is based on the need to put into practice the knowledge and studies developed through geometry. In addition, the authors of these studies have been based on the use of visual tools, which use different spatial dimensions, to facilitate the understanding of geometry in mathematics. Therefore, we can affirm that the results of the analysis of these studies would be applicable to the teaching of technical drawing, since it is based on geometry.

The provenance of the selected studies was Turkey (3 studies), Spain (3 studies), Latvia (1) and Israel (1). 5 studies used qualitative and 3 quantitative methodology. The total number of participants adding up the 8 studies was 400. One of the studies did not indicate the exact number of participants, so it has not been included in this summation. Of the participants studied, 1 was primary school, 31 were secondary school, 304 were university students, and 64 were of different ages and / or educational levels.

Among the software studied we find:

- Various 3D modelling programs (2 studies) and 3D printers (1 study), several computer programs (e.g. HiperCard stack) (1 study).
- *ArchiCAD* is a CAD[16] software for building information modeling (BIM).
- Revit Architecturee is a software of construction information modeling (BIM), which allows the user to design with modeling and parametric drawing elements.
- Augmented Reality (AR) software allows a user to view part of the real

[16] Computer-aided design.

world through a technological device with graphic information added by this device.

- *3D eDrawings viewer* is a communication tool of 2D, 3D and Virtual Reality/ Augmented Reality, for the parties involved in the design process to the manufacture of 3D objects.
- *Cabri 3D* (2 studies) is a software to explore the geometry of space. It allows to build, visualize, manipulate, measure or incorporate data in three dimensions in all kinds of objects: straight lines, planes, cones, spheres, polyhedra etc.

4 studies applied some of these softwares in the subject of Geometry or Spatial Geometry (Mathematics) with students of primary or secondary level. Half of them used Cabri 2D. 3 studies were carried out with engineering students, in the subject of Engineering Graphics, using different 3D design softwares.

The results of these studies indicate that the educational use of 2D-3D software improves the understanding of spatial geometry and mathematics (Yildirim, 2018, Veide & Strozheva, 2015 and Kösaa & Karakua, 2010).

Five studies measured the visual-spatial abilities of the participants before the intervention, concluding in an improvement of them in all the studies (Veide & Strozheva, 2015; Melgosa Pedrosa, Ramos Barbero & Román Miguel, 2014; Melgosa Pedrosa, Ramos Barbero & Baños García, 2013; Kösaa & Karakua, 2010 and Güven & Kosa, 2008). This means that visual spatial intelligence can be increased thanks to the use of 2D-3D computer tools.

Finally, Widder & Gorsky (2013: 89) demonstrated a cognitive load reduction for Geometry learning of secondary students who used 3D software, indicating that students with low visual-spatial intelligence "use software tools much more than good visualizers" (with greater visual-spatial intelligence), "mainly to make measurements." Those "with relatively high spatial ability skills use software sparingly, primarily to rotate geometric objects".

		Method					Educational level						Results/ Improvements			
Author (year)	Country	Qualitative	Quantitative	Mixed	Number of participants	Study duration	Primary	Secondary	University	Other/ Mixed aged	2D- 3D tools (software)	Subject of application	Geometry understanding	Mathematic knowledge	Visual- spatial skills	Cognitive load
Yildirim (2018)	Turkey	•			30	1 ay		•			3D modelling programs and 3D printers	Not specified	+	+		
Veide & Strozheva (2015)	Latvia	•			17	6 m			•		ArchiCAD, Revit Architecturee and augmented reality (AR) software	Civil Engineering graphics	+		+	
Melgosa Pedrosa *et al.* (2014)	Spain		•		17	2 ay			•		ILMAGE_SV	Engineering graphics			+	
Melgosa Pedrosa *et al.* (2013)	Spain		•		270	2 ay			•		3D eDrawings viewer	Engineering graphics			+	
Widder & Gorsky (2013)	Israel	•				1 ay		•			3D software program	Geometry (Maths)				+
Kösaa & Karakua (2010)	Turkey	•			24	8 w				•	Cabri 3D	Spatial geometry (Maths)	+		+	
Güven & Kosa, (2008)	Turkey		•		40	2 d				•	Cabri 3D	Spatial geometry (Maths)			+	
Gutiérrez (1996)	Spain	•			2	2 s	•	•			Several computer programs (e.g. HiperCard stack)	Spatial geometry (Maths)	•[17]			

Study duration abbreviations: y (year), ay (academic year), m (month), w (week), s (session).
Studied (•), improvement (+), not improvement (-).

Table 3. Data extraction. 2D- 3D tools and drawing learnin

[17] The results of the investigation are incomplete. Not described in this article for a congress.

DISCUSSION

Our initial hypothesis suggested that the application of videogames and ICT tools (2D- 3D software) in the subject of CLIL technical drawing could improve the understanding of complex contents thanks to the increase of visual-spatial intelligence, at the same time as it could improve L2 language skills, in a more motivating and enjoyable context.

The theoretical framework served as an antecedent to establish the suggested relationships between the different agents of our research question. The results of the literature review support the statements that different authors threw on the issues in question in the theoretical framework.

In relation to the stimulation of visual intelligence through video games and 2D- 3D software, our results show an improvement of it as stated by Moral Pérez *et al.* (2014) and Moral Pérez *et al.* (2015), Garmen *et al.* (2019), Moral *et al.* (2018), Lovin (2018) and Cutumisu *et al.* (2014). This translates into a better understanding of visual-spatial concepts applied to technical drawing. Therefore, we understand that the educational use of these tools is not only viable, but determinant to facilitate the understanding of contents that may seem abstract and complex, added to a cognitive load reduction for technical drawing of secondary students (as indicated by Widder & Gorsky, 2013). These tools offer the possibility not only of spatially visualizing the objects, but of moving them, modifying the types of views, making measurements, etc.

We agree with Sylvén & Sundqvist (2012) when affirming that these technological tools contribute to L2 improvements since they provide an environment in which its used is easier, they facilitate interaction and communication with the tool itself as well as with other users (students, teachers or native speakers). The results of our literature review indicate a general improvement of 75% in the language skills measured in the different studies after the interventions with VG, in addition to the

learning of different contents in L2 (Bédi *et al*., 2016; Neville, 2014 and Dourda *et al.,* 2014). This shows doubly that VG not only contribute to the learning of language but also can integrate the learning of content, as in our particular case those referred to technical drawing. Howard and Do (2017: 42) consider the necessity “to introduce scaffolds to support L2 learners” in these contexts.

Enjoyment is necessary for the success of these educational practices. Three of the articles studied in our research measured the enjoyment of the participants. The three stated that participants enjoyed the learning experience through VG in accordance with the ideas of Aliciardi *et al.* (2016).

According to Casado Ahumada (2016) "the motivational potential of video games can be multiplied when they are developed within the framework of the methodology of task-based learning and CLIL. We consider that motivation during learning is an essential issue in our CLIL subject. The results of our study indicate that the use of VG and 2D-3D software (Lovin, 2018, Carvo-Ferrer, 2015, Cardoso *et al*., 2015) can increase students' motivation for learning content and L2. As stated by Aliciardi *et al.* (2016), the motivating capacity of VGs is due to the constant challenge they propose. But we must consider that the lack of motivation of one or more participants in a group activity (with videogames or other ICT tools) can negatively affect the rest of the participants, with its consequent secondary demotivation (Vosburg, 2017).

It is important to design video games taking into account different forms of language and content learning and gaming for each student (Vosburg, 2015; Hitosugi *et al*., 2014) so that a meaningful and not frustrating learning takes place. Due to individual differences in students' attitudes and learning capacity, VGs and softwares must be carefully selected. We must not only take into account the possible game preferences of our students but also the design of the games or tools centered on the student-player, as indicated by Sajjadi *et al.* (2017), suitable and adaptable to them (Casañ Pitarch, 2017). An erroneous choice for excess of difficulty can be frustrating.

Likewise, a game or software without incentive can be boring or demotivating. Hence the importance of knowing how to choose according to the students, their skills, tastes and needs.

We find limitations of a methodological nature in our study. The variety of articles found, both in their design and in the measured indicators, in the instruments used or the VGs or softwares used, make a more exhaustive and reliable data analysis difficult. In addition, for the case in question of our hypothesis, we have not found any bibliographic reference, so we had to divide the research question into three pillars that we have joined later. However, we believe that the results give certainty to our initial hypothesis.

CONCLUSIONS

This study suggests that the use of videogames and 2D-3D software can improve visual-spatial abilities and, therefore, improve the visual intelligence of its practitioners. This is crucial for high school students who are studying technical drawing and who may have difficulty understanding certain contents. At the same time, these tools are used with positive effects on language learning. Therefore, applied to the subject of CLIL technical drawing, they can have positive effects on both content and different language skills learning, in an environment of enjoyment and more motivating than traditional learning.

The choice of technological tools is of utmost importance for the experience to be successful, both in terms of knowledge acquisition and language improvement as well as in the enjoyment of it. Keeping students motivated requires an equal dose of challenge and reward, and it is important that they feel supported (use of scaffolding, progress in the tasks, positive reinforcement, etc.).

Educators and creators of videogames/ softwares must take into account the competencies and objectives so that these tools are properly incorporated into the curriculum, as well as foster cognitive challenges to achieve meaningful student learning.

Given the absence of studies that link the concepts discussed in this paper, we consider it necessary to put them into practice through a future pilot study (practical research project) comparing the traditional teaching of CLIL technical drawing with the teaching of CLIL technical drawing mediated by VG and 2D-3D software.

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ANNEXES

The following annexes (I, II and III) are the data collection tables of the articles selected for each section of this study. They contain partial and original texts of the authors of the articles. The data collected: Name and surname of the authors, date and country of the study, type of study, methodology, participants (poblation and academic level or age), subject of application, time of study, instruments, indicators, data sources, video games or 3d tools specifications, students possible my or other improvements, effects on results, conclusions and comments.

ANNEX I. DATA EXTRACTION. VIDEO GAMES AND MULTIPLE INTELLIGENCES

VIDEO GAMES AND MULTIPLE INTELLIGENCES

AUTHORS (YEAR)	COUNTRY	TYPE OF STUDY / METHOD	PARTICIPANTS/ POBLATION / ACADEMIC LEVEL (AGE)	SUBJECT OF APPLICATION	TIME OF STUDY	INSTRUMENTS / INDICATORS	VIDEO GAMES SPECIFICATIONS	STUDENTS POSSIBLE MI OR OTHER IMPROVEMENTS	RESULTS	COMMENTS

Garmen et al. (2019)	Spain (Asturias and Madrid)	Analytic investigation (quantitative).	372 primary school students (aged 5- 9)	1 academic year.	TOI: Successes, time and accuracy for each game and school year.	*TOI* (Tree of Intelligences) software, a digital tool to evaluate multiple intelligences and perform interventions through video games.	Multiple Intelligences testing	9 out of 10 games had a normal distribution and there were no gender differences in most games, but there were differences in relation to the school year. TOI software has the potential to be a suitable instrument for the evaluation and intervention of multiple intelligences. Tool such as TOI, which allows teachers to discover students' intelligence profiles or strong and weak areas, opens up the possibility of knowing which learning style best suits students' profiles or discoveries which activities they feel most comfortable with in order to work towards more personalised, inclusive education, taking into account the fact that everyone is different and therefore should not learn in the same way.	
Del Moral et al. (2018)	Spain (Valencia)	Experimental design (EG and CG)	119 primary education students.	8 m (1 h/ w)	30 indicators associated with the three intelligences mentioned above (ten per intelligence) were extracted from the Evaluation Questionnaire,developed by Prieto and Ballester (2003).	Videogames available online on educational databases, grouped together according to the subject to which they belong, their contents and the intelligence development to which they contribute.	Logical-mathematical, naturalistic and linguistic abilities	A widespread increase in children's learning levels in logical-mathematical, naturalistic and linguistic abilities with regard to the three intelligences under study for all the subjects or areas of knowledge involved, after their participation in this project.	Students played with a selection of user-friendly and easily accessible educational videogames and/or digital games, the contents of which are connected with the curriculum.
Lovin (2018)	USA (Arizona)	Qualitative case study.	12 private high school math and/or science teachers.	¿?	A triangulation of data using demographic questionnaires, an interview, and a 50-minute classroom observation.	Digital math gaming	Motivation to engage in math activity and knowledge acquisition.	The participant teachers' perspectives on integrating math gaming as part of a collaborative tool is a valuable addition to their math and/or science pedagogy. All participant teachers reported that the math gaming provided the students with an alternative learning strategy to contribute to the course objective. The value of math gaming can be categorized into two primary areas to include motivation to engage in math activity and knowledge acquisition as a result of engagement.	It investigates private high school math and/or science teachers' perspectives on math gaming in the classroom.

Sajjadi et al. (2017)	Belgium (Brusels)	Descriptive and analytic investigation (qualitative and quantitative).	308 international population of frequent gamers (survey).		/	Online survey: measuring the participants' intelligences and their preferences for specific games. Game mechanics (methods invoked by agents, designed for interaction with the game state)"	*Multiple VG*	/	We can conclude (1) that gamers' MI dimensions and their game preferences have multiple strong relationships; (2) that the relationships between MI dimensions and game preferences cannot be explained only by game genres; and (3) evidence-based mappings between game mechanics and the different MI dimensions exist, which can facilitate the use of the MI theory for player-centred game design. Note that these mappings could also be used in other contexts than player-centred game design, e.g. to dynamically adapt learning games to the player or to stimulate the development of certain intelligences.
Del Moral Pérez et al. (2015)	Spain/ Colombia	Qualitative and experimental: case study	101 first cycle of primary education students (aged 6-7).	Matts, Knowledge of the Environment and Music.	1 academic y.	Grid for the analysis of the videogame's content. Questionnaire for Multiple Intelligence Assessment	*Naraba World*	A widespread increase of all intelligences.	The introduction of suitable videogames in the classroom and their systematic exploitation promotes MI development amongst primary education children. In particular, measuring operations, mathematical calculations, counts, shape and size identification and classification, relationships and correspondences, etc., presented in an entertaining way by means of animations, graphics and drawings, together with the activities that promote body care (healthy diet and personal hygiene), facilitate learning and improve MIs.
Cutumisu et al. (2014)	USA (California)	Study 1 is correlational. Study 2 is correlational and experimental. Study 3 is correlational.	College and middle-school student: Study 1: 109 community college students (aged 15-52). Study 2: 31 students (aged 18-24). Study 3: 97 6th-grade middle-school students (aged 11-12)	Graphic design	1 session: Study 1: 16 minutes. Study 2: 36 minutes. Study 3: 21 minutes.	Study 1: - Learning Choices: negative feedback/ revision. - Internal Learning Outcomes (post-test): Poster quality, learning of the graphical design principles. Study 2: - Learning Choices: negative feedback/ revision. Internal Learning Outcomes (post-test):	*Posterlet*, a game designed to assess students' choices to seek negative feedback and to revise, in which students learn graphical design principles while creating posters. The *Posterlet* game is an instance of a choice-based	Learned more graphical design principles.	Results showed that the game helped students learn: students who played Posterlet before completing the post-test learned more graphical design principles than students who only completed the post-test. Moreover, the choices to seek negative feedback and to revise can predict learning and be used as valid outcome measures for learning. We present a first-of-kind examination of students' choices to seek feedback and to revise, as well as of students' learning outcomes based on these choices, which can be used to develop and evaluate models of instruction that help students make informed learning choices.

	Poster Ranking and Justify Ranking. Study 3: - Learning Choices: negative feedback/ revision. - Internal Learning Outcomes: Post-test combines the measures of the Principle Selection category from Study 1 and Poster Ranking from Study 2, summing their normalized Z-scores.	preparation for future learning (PFL) assessment designed to measure two behaviours important for learning: 1) the choice to seek negative feedback and 2) the choice to revise.

ANNEX II. DATA EXTRACTION. VIDEO GAMES AND L2 LEARNING

VIDEO GAMES AND L2 LEARNING

AUTHORS	DATE STUDY/ COUNTRY	TYPE OF STUDY /METHOD	PARTICIPANTS/ POBLATION / ACADEMIC LEVEL (AGE)	L2 / SUBJECT OF APPLICATION	TIME OF STUDY	INSTRUMENTS / INDICATORS/ DATA SOURCES	VIDEO GAMES SPECIFICATIONS	EFFECTS ON	RESULTS	CONCLUSIONS: POSSIBLE IMPROVEMENTS
Howard & Do	2017 USA Tenesse	Comparative case study (qualitative)	34 9-12 year old native Korean speaking school children residing in a small town in the American Midwest. Total sample: 34 participants Native English speaker group: 28 Non- native English speakers: 5.	English	5 sessions	Textual analysis method: 5 synchronous chat conversations between native and non-native (Korean) speakers of English were selected to study the use of politeness in linguistic interactions.	*Quest Atlantis* (QA) is a digital game built via the Active Worlds immersive virtual environment to create learning opportunities for children aged 9-12.	The use of politeness in linguistic interactions.	The 2 learners' politeness measures were neither in line with native speakers, nor with each other. This imbalance can indeed present the L2 learner as able to communicate pragmatically, but, in actuality, the learners may be less in control of their image than might be assumed. This study stands as an argument to introduce scaffolds to support L2 learners' pragmatic strategies in online spaces as online spaces are where future learners are likely to encounter native speakers and because the social cost of L2 failure after they leave the safe space is higher than at school.	

Enticknap-Seppänen	2017 Finland	Case study, employing the sociocultural and ecological approach to language learning to interpret the social interactions of gameplay. (qualitative)	Two groups of first year tourism students were split into eight teams of four to six persons and played the game two teams at a time, during four gameplay sessions.	English	4 game sessions.	Teacher researcher's observations of gameplay sessions, learning diaries and preliminary and post-gameplay online open questionnaires.	The game consists of a 2D online audio-visual animation made with the widely available online animation software, *Go Animate*. It presents seven tourist guiding events where the guide behaves inappropriately in customer service situations. These include meeting the tourist group, explaining the itinerary, safety procedures, recommending places to eat, informing, describing monuments, and dealing with an emergency.	Learning engagement and oral communication in English (social interaction).	The results showed that once-off gameplay sessions afforded engagement and oral communication in the L2. However, the questionnaire responses and learning diaries implied that the students had high expectations of learning engagement and oral skills development which were not completely fulfilled due to game design constraints. This suggests that although much occurs during single instances of gameplay, a participatory approach involving education professionals and learners in educational game design is warranted to fully optimize L2 appropriation within the game environment.	Gameplay sessions afford engagement and oral communication in the L2.
Vosburg	2017 USA Pensilvania	Case study (qualitative and quantitative data)	7 students of third semester German classes (19.6 years old) from an American university playing with German native speakers.	German	8 w 2 sessions of 90 min game time/week resulting in 24 total hours of game play.	- Pre- and post-oral proficiency exam. - Pre-, mid-, and post-individual, and post-group structured interviews. - Gaming journal.	*World of Warcraft* (WoW) as an extramural activity. It is a virtual world in which players generate characters that interact with other players and the online gaming environment via an avatar.	- Group interactions and motivation in relation to gaming and language learning. - Perceptions about how interactions and motivation possibly affect their target language production.	Participants reported during interviews and written journal entries that a lack of shared interests and motivation (learning and gaming) negatively affected the groups' target language participation. The findings additionally suggest that a trained foreign language instructor paired with a motivated learner may result in increased participation; however, these increases may be temporary if a group's relationship does not extend beyond the shared goal of foreign language improvement.	While much CALL research indicates that gaming provides a viable language learning option for many, something as simple as group membership can severely hinder the possibilities of language learning and motivation at an individual level. As seen in on of the studied groups, its combination of participants derailed much of the conversation, thus reducing group members' interactional opportunities.

Bédi et al.	2016 Iceland	A mixed-method approach consisting of a questionnaire, an interview and a video.	6 learners of six different nationalities (aged 22-31) with a A1 level of Icelandic.	Icelandic	13 weeks: 2/w, 90 min lessons.	The game's ultimate goal is to promote learning of language and culture based on real language use with virtual characters acting like native speakers. An interview and a video recording of each participant while playing was used.	*Virtual Reykjavik* is a video gamelike environment where learners interact with virtual characters – Embodied Conversational Agents (ECAs). This game enables learners to practice speaking and listening skills, to learn about the language and culture by solving various tasks.	Spoken language skills and culture contents.	Five out of six learners found the game educational, of which three learners reported they learned (1) spoken language skills when initiating a conversation, and (2) about cultural sights and buildings in downtown Reykjavik. A gap between a passive and an active use of language can be bridged when learners get to practice the language in a conversation with virtual agents. The game may help facilitate face-to-face communication in reality.	It can help to practice and learn spoken language skills and about cultural sights and buildings.
Cerezo et al.	2016 USA Georgetown	Experimental design. (quantitative and qualitative)	70 college-level students of beginning Spanish: - EG1 (video game guided induction) - EG2 (deductive instruction) - 1 EG (uninstructed).	Spanish	Before taking part in the study, participants had received 10 weeks (approx.. 25 h) of formal exposure to Spanish under a communicative approach.	- Participants' ability to produce orally and in writing the targeted "gustar" structure by 2 productive tasks (controlled oral and written production). - Explicit knowledge by one receptive task (multiple-choice written recognition). Pre-tests/ Immediate /delayed post-tests (last both included different experiencers and "liked things").	*The Gustar Maze* video game is used to guide induction to gradually promote deeper processing of the target language structures (*gustar* verb in this study). It is sought to reap the reported benefits of task essentialness (to focus learners' attention on the target form), scaffolding (to gradually introduce the complexity of the form), right/wrong feedback (to trigger hypothesis and rule formulation), and guiding questions.	Complex grammar ("gustar·" verb).	Results revealed that while both instruction groups improved across time, outperforming the control group, the guided induction group (via a video game) achieved higher learning outcomes on all productive post-tests (except immediate oral production) and experienced greater retention. Additionally, the think-aloud protocols of the guided induction group revealed high levels of awareness of the L2 structure and a conspicuous activation of recently learned knowledge, which are posited to have contributed to this group's superior performance. These findings thus illustrate, quantitatively and qualitatively, the potential of guided induction for the development of complex L2 grammar in online learning environments.	EG1 achieved higher learning outcomes on: - Controlled written production - Multiple-choice written recognition - Cognitive processes during the video game guided induction treatment.

Ibrahim	2016 USA Arizona	Qualitative case study design.	Pilot study: 3 learners of Arabic with different levels of Egyptian Arabic proficiency. Follow up study: 4 university advanced Egyptian Arabic students.	Egyptian Arabic.	- 4 weeks of unsupervised interaction with the game (minimum of 2 h/w) - 4 sessions for study.	- Pre-study questionnaire and stimulated recall interviews. - Think-aloud protocol (audio-recordings of gameplay sessions). - Gameplay recordings/walkthroughs (video recordings of the players' actions and interactions). - Self-reported journals (each time they played the game). - Semi-structured interviews.	*Baalty* is an educational simulation-management game designed to teach entrepreneurship skills and business ethics to Egyptian children and teenagers by simulating the process of managing a retail store in Upper Egypt.	- Game users interaction. - L2 proficiency.	The pilot study suggested that L2 gaming can be cognitively overwhelming to low proficiency learners. Data interpretation of the follow up study revealed that the explicit interactivity of play situated in-game discourses in the embodied virtual world of the game creating several multimodal affordances for languaging these discourses. The analysis also demonstrated that gamers' background, especially their gaming experience, L2 proficiency, and L2 learner identity, mediated and shaped their interactions with the game and determined the learning potential of the game. This research project demonstrated that player-game interaction is a dynamic, complex, and multi-layered activity, and that games are engaging multidimensional semiotic spaces that can afford purposeful task-based languaging activities and situated L2 use in the engaging and situated context of play.	*Baalty* is good tool for L2 learning, especially for proficiency learners of egyptian. A better domain of L2 determines the right learning potential of the game.
Calvo-Ferrer	2015 Spain Alicante	Experimental design.	65 university students of English as a Second Language in the second year of the degree in Translation and Interpreting holding a B2-C1 level of English. 2 groups with equivalent stand-alone materials: (1) an educational game called The Conference Interpreter and (2) a booklet replicating its contents.	English.	5 days.	Questionnaires to collect quantitative data: (1) a knowledge test on mobile operating systems vocabulary given as pre-test, post-test and delayed test, (2) a post-test questionnaire on student motivation as developed by Guay, Vallerand and Blanchard (2000), and (3) a post-test questionnaire on students' perceived learning outcomes.	*The Conference Interpreter.*	- L2 vocabulary acquisition. - Perceived learning gains. - Motivation.	The results of pre-, post- and delayed tests showed that students that had access to the contents via the video game performed statistically better in the short run, found the materials more appealing and believed their vocabulary skills had developed further than those in the control group. However, the regression model showed that the actual enjoyment of the game seemed to have no effect on the students' learning outcomes, neither according to their own estimation nor as determined by testing. Of greater importance was extrinsic motivation: their desire to play based upon expected learning gains, prior knowledge of tested L2 vocabulary and perceived difficulty of the educational contents.	Control group (contents without VG) same learning results as experimental group (same contents with VG). EG more motivated.

Cardoso et al.	2015 Canada	Descriptive investigation.	4 Chinese students enrolled in an intermediate-level ESL conversation course at a Canadian university.	English	4 w. (1 session of 15-20 minutes game-playing/ week).	- A survey after the final gaming session to obtain reactions to the game on their L2 learning experience. - Open interviews to students and teacher´s perceptions of Spaceteam ESL.	*Spaceteam* (only level 1 studied) ESL: A mobile video game as a classroom tool created to develop oral fluency, and to examine student and teacher perceptions of the game. Players must interact orally with team members to communicate and/or carry out instructions to pilot a spaceship. They must be both intelligible and efficient (fast) in speaking so that their teammates can successfully interpret the instructions within the time frame.	- Oral fluency. - Student and teacher perceptions of the game.	Spaceteam ESL has great potential as a tool to help develop oral fluency and pronunciation in the L2 classroom. It may contribute to some of the important factors that promote L2 learning: it increases learners' (and possibly teachers') motivation, creates a comfortable learning environment, and fosters teamwork and consequently peer teaching (including peer-feedback).	
Vosburg	2015 USA Pensilvania	Case study (qualitative and quantitative data)	7 students of third semester German classes from an American university playing with German	German	8 w (2 sessions of 90 min game-time/week): resulting in 24 hours of game play.	- Pre- and post-oral proficiency exam. - Pre-, mid-, and post-individual, and post-group structured interviews. - Gaming journal.	*World of Warcraft* (WoW) as an extramural activity. It is a virtual world in which players generate characters that interact with other players and the online gaming environment via an avatar.	Participant activity levels: word counts, lengths of run, English used, subject-verb-agreement (SVA) and finite verb placement.	Participants activity levels fluctuated week-to-week. Word counts, runs, English usage, and SVA and placement varied each week. However after the fifth week, an upward trend in spoken production, SVA and placement control, with a reduction in English is observed. Oral exam scores also exhibited increases in these same categories, and each participant increased their oral proficiency scores. Activity levels and outcomes were shown to be influenced by, among others: language and gaming motivations, group dynamics, in-game tasks and dungeons, stress, and collaborative interaction with the language guides. Activity levels and outcomes are in many ways unpredictable in this environment.	Increases in spoken production, SVA and placement control, with a reduction in English use after some weeks of gaming. They can be affected by motivations, group dynamics, in-game tasks, stress, and collaborative interaction with the language guides. This gaming positively influences but may not be the most efficient way of learning for everyone. It is important to design differing perspectives of language learning and gaming for each participant.

Hitosugi et al.	2014 USA	Mixed-method study.	20 participants in Studies 1 and 2 consisted of two classes of intermediate high to advanced low level Japanese at a US university, with a total of 20 participants (22.33 aged) Study 1= 9 Study 2 = 11.	Japanese	Five 50-minute class sessions.	Studies 1 and 2: - "Food Force" vocabulary tests (pre-, post-, delayed) - End-of-unit affect survey. Study 2: + Textbook vocabulary tests + Interviews.	*Food Force (FF)* is a UN-sponsored off-the-shelf videogame, on learner affect and vocabulary learning and retention in a Japanese as a second/foreign language classroom. It is a non-violent, educational, humanitarian videogame developed by the UN World Food Program (UNWFP) in 2005 to raise the awareness of school children and adults about world hunger.	Vocabulary learning and retention. Gaming affect.	Positive impact on learner affect and a preference for game-mediated activities over conventional exercises. Participants in both groups recalled new "FF" vocabulary five weeks later at the same rate as immediately after the unit, while they significantly forgot words from the textbook. Study 2 resulted in better learning of "FF" words than Study 1. Though there was significant positive effect on average, individual differences were found in students' attitudes and vocabulary retention. Vocabulary retention using FF was significantly better than with the conventional method, regardless of how vocabulary was introduced. The majority of students reported that they enjoyed the FF unit more than the traditional unit. FF particularly seemed to benefit those who have good metacognitive awareness of their language learning.	Digital game-based learning facilitates deep learning.
Neville	2014 USA North Carolina	Mixed-methods study (EG/ CG).	22 monolingual university students (18-23 aged) with varying backgrounds and proficiency in the German language.	German	Two second-semester introductory German language courses at an arts university. 75 min classes.	The study seeks to articulate the influence that gameplay has on the way learners configure story maps about the sociocultural and linguistic practices embedded as instruction in the environment, and whether learners subsequently accessed these maps outside of the environment in order to structure the written narrative tasks.	The study utilized a custom-built *3D-DGBLL environment*, employing a first-person player interface to teach German recycling and waste management practices within the grammar context of two-way prepositions. A custom-built environment was required as no commercial off-the-shelf (COTS) game is currently available for teaching these topics. Creating the environment from	German two-way prepositions and specialized vocabulary.	Immersion in the 3D-DGBLL environment influenced the manner in which the second language was invoked in these written narratives: Participants in the experimental group produced narratives containing more textual indicators describing the activity associated with the recycling and waste management systems and the spaces in which these systems are located. Increased usage of these indicators suggest that participants in the experimental group did indeed rely on story maps generated during 3D gameplay to structure their narratives, although stylistic and grammatical features of the narratives suggest, however, that changes could be made to the curricular implementation of the 3D-DGBLL environment.	

							scratch allowed for tighter curricular integration, the development of more effective workflow patterns, and granted a closer examination of the affordances and limitations of these environments.			
Chik	2014 China Hong Kong	Multiple case study approach (exploratory study) (multi method).	10 1st year Chinese-speaking undergraduates in an English- medium Hong Kong university.	English	12 m.	Learning practices in five dimensions: location, formality, pedagogy, locus of control and trajectory. Spoken and written data, discussion threads and "trajectory" (to reflect gaming practice management over time and how learning is situated in a person's past and future career). Data from gaming sessions, stimulated recall, focus group discussion, individual interviews and online discussion forums	Different online video games that participants used to play.	L2 gaming and learning practices in young people's everyday lives.	Gamers exercise autonomy by managing their gameplay both as leisure and learning practices in different dimensions (location, formality, locus of control, pedagogy and trajectory). At the same time, gameplay-as-learning practices are supported by wider communities of digital gamers who take on roles as language teachers and advisers. The paper suggests that activities in these dimensions mediated learning autonomously and from community, and discusses the research and pedagogical implications for L2 gaming and learning.	The extended online gaming communities provide support in both L1 and L2 through paratexts and language learning advices.
Dourda et al.	2014 Florina, Greece.	Quantitative case study.	17 chosen randomly students (aged 11- 12) attending a Greek Public Primary School of Thessaloniki.	English	8 w.	Students' performance was evaluated through knowledge tests and various complex tasks throughout the game play, involving writing and reading skills. - knowledge test (pre/ post) consisted of 30 true/false or multiple-choice questions to	*Whodunit* (for "Who done [did] it?") is a plot-driven, web-based detective game. A designed educational geography computer game, utilizing QR Codes and Google Earth for teaching English Language to	Language: writing and reading. Content: problem solving challenges regarding the use of geography in realistic contexts.	Students showed positive attitudes towards the game and the post-test results have significant differences compared to those of the pre-test, in terms of vocabulary acquisition and reading skills in the foreign language and geography knowledge. The results also showed that the collaboration required by this game, allowed the students to interact in a controlled environment, where they	Post-test improvement of vocabulary acquisition and reading skills in the foreign language and geography knowledge.

measure students' performance in geography and English vocabulary - Satisfaction/feedback questionnaire post intervention.	Greek Primary School students. 6 levels.	undertook roles and responsibilities.

ANNEX III. DATA EXTRACTION. 2D- 3D TOOLS AND DRAWING LEARNING

3D TOOLS AND DRAWING LEARNING

AUTHORS (YEAR)	COUNTRY	TYPE OF STUDY / METHOD	PARTICIPANTS / POBLATION / ACADEMIC LEVEL (AGE)	SUBJECT OF APPLICATION	TIME OF STUDY	INSTRUMENTS / INDICATORS	3D TOOLS (SOFTWARES)	STUDENTS POSSIBLE IMPROVEMENTS	RESULTS	COMMENTS
Yildirim (2018)	Turkey	Case studies (qualitative)	30 secondary school students of 6th grade (aged 12)	Not specified	1 academic year.	Semi-structured interview form	Not specified	Developing effective learning environments and facilitating understanding in Science and Mathematics teaching.	3D modelling programs and 3D printers can be said to be appreciated by users. 3D modelling programs are effective in developing fast prototypes and making easy drawings. 3d printers has an important impact on developing effective learning environments and facilitating understanding. They offer freedom in material development, and success in embodying the imagination. They can be effective in Science and Mathematics teaching. Specially long output time and high cost of output can be among the most important limitations of their use.	
Veide & Strozheva (2015)	Latvia	Practical education (qualitative)	Civil engineering undergraduate 2nd year students	Civil Engineering Graphics.	Spring semester, 2 hours per a week.	/	ArchiCAD, Revit Architecturee and augmented reality (AR) software.	Spatial skills and understanding of the shape and objects geometry.	The use of different visualization methods in the educational process is a good way to get more sustainable knowledge, cognitions, and understanding in a variety of natural subjects of engineering education. Introduction of the modern BIM software in education process will allow to be competitive and flexible in a rapidly changing information technology environment. A certain number of drawings and models carried out manually is necessary for the development of spatial skills and understanding of the shape and objects geometry. The students apply AR technology with pleasure and great interest, consequently, such important components of cognition as motivation and wish, will be enhanced.	

Melgosa Pedrosa et al. (2014)	Spain	Experimental design. An experimental group that studied with the ILMAGE_SV web application and a control group taught with traditional methods (quantitative)	Students of engineering graphics.	Engineering graphics.	2 years	/	ILMAGE_SV: an interactive learning manager for graphic engineering to develop spatial vision. Is an asynchronous web-based learning tool that allows the manipulation of objects with a 3D viewer, self-evaluation, and continuous assessment.	Spatial Visualization Ability	Both methods (ILMAGE_SV web application and traditional method), with regard to the development of spatial vision, are in general equal. Nevertheless, ILMAGE_SV is more efficient for students who experience greater difficulties with spatial vision and for students with no prior knowledge of technical drawing. In addition, student learning may be monitored, which saves a significant amount of time for the teacher, as both correction and grading are automatically performed.	No full text.
Melgosa Pedrosa et al. (2013)	Spain	Quasi-experimental pre-test/post-test design (quantitative)	270 engineering graphics students.	Engineering graphics.	5 weeks in each year. More 2 years	Mental Rotation Test (MRT). Experimental trials in the classroom and a user satisfaction survey.	Interactive Learning Management System (ILMS). 3D eDrawings viewer.	Spatial Visualization Ability	The use of this tool improved Spatial Visualization Ability (SVA) among students generally and was even of greater effectiveness for those students that accessed engineering courses with no prior knowledge of Technical Drawing	The ILMS_SVA consists of: (1) a Content Management System (CMS); (2) a preliminary level assessment test; (3) a web-based tool for exercise management and self-assessment incorporating a 3D viewer that functions as an interactive tutorial (IT), allowing the manipulation of 3D objects in every exercise; (4) a database.
Widder & Gorsky (2013)	Israel	Qualitative research	High school students.	Spatial geometry (Maths)	/	/	3D software program	Cognitive load reduction.	Students with relatively low spatial ability skills use the software's tools much more than good visualizers, primarily for making measurements. Students with relatively high spatial ability skills use the software sparingly, primarily to rotate the geometric objects.	

Kösaa & Karakua (2010)	Turkey	Applied practical study (qualitative)	24 prospective high school teachers who had a mathematics degree and were attending the postgraduate teacher training course.	Geometry (Maths)			Cabri 3D	Spatial visualization skills and the better understanding of geometric concepts and geometric relationships.	Cabri 3D is potentially very useful software for learning and teaching spatial analytic geometry, and it facilitates understanding by visualizing. The dynamic nature of dynamic geometry software provides students to learn geometric concepts and to explore and visualize geometric relationships easily.	
Güven & Kosa (2008)	Turkey	Experimental design (quantitative)	40 student mathematics teachers.	Geometry (Maths)	8 w.	"Purdue Spatial Visualization" (PSV) test.	Cabri 3D	Spatial skills.	These computer supported activities contributed to development student mathematics teachers' spatial skills.	
Gutiérrez (1996)	Spain	Case studies (qualitative)	Primary and secondary grades students (aged 7 to 17)	Geometry (Maths)	2 days (1 hour/d).		Several computer programs that represent polyhedra in perspective and that allow the users to rotate them (e.g. HiperCard stack).		The study raise some questions related to the analysis of primary and secondary school students' behaviour when solving tasks in 3-dimensional geometry by using dynamic software. The analysis focuses on students' ways of using screen images, the mental images they create, and the processes and abilities of visualization they use to solve the tasks.	The results of the investigation are incomplete. Not described in this article for a congress.