

TAM Applied for Serious Video Games: A Systematic Literature Review

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Abstract

Since their inception, video games have greatly interested different types of users and organizations, and the academy is not an exception. The principal purpose of serious video games in the academy is to discover new ways to interact with students and strengthen learning and teaching. Video games in education are constantly used in a greater scope to improve the educational process. On the other hand, it is essential to consider the characteristics that must be considered in these types of tools so that they fulfil their purpose without neglecting the interest and motivation of the player. The objective of this work was to perform a systematic review of the topic “technological acceptance models (TAM) applied to serious video games”. The investigation was done by performing searches in 6 scientific libraries to obtain a corpus of papers published between 2015 and 2021. Consequently, a lexical analysis was performed, and 4 clusters were identified about this topic: i) Emotions, social influence, and gratifications; ii) Structural equations; iii) Educational challenges with technology, and iv) The technology acceptance model.

Keywords

Technology Acceptance Model, TAM, serious games, SLR, Covid-19

1. Introduction

Information technologies have grown exponentially, which has caused an improvement in people's lifestyles around the world. It is interesting to note that all the Sustainable Development Goals (SDG) adopted by the United Nations in 2015 were achieved with technological resources. Although there are digital gaps in all the objectives, SDG 4 is classified as the most relevant objective that can be reached with technology. Furthermore, it is well known that the educational institutions that invest more in digital infrastructure achieve a better quality of education since it contributes to the increase in the availability of digital literacy content and improves the quality of access to digital

resources (García-Avilés, 2021). The digital gap in education can be reduced with the intervention of the public and private sectors by increasing the budgets for research, science, and innovation. Innovation in the way teachers teach and students learn. One of the keys to educational innovations is the use of different devices such as mobile devices (Criollo-C et al., 2021) and the use of various tools such as video games.

Nowadays, serious video games have been applied inside of the educational field, mainly in higher education institutions. The principal objective of the application of video games is to engage learners in complex problem spaces that mimic real-world situations without importing unwanted constraints and risks of the real world. An example of the application of serious games in higher education institutions can be found in Spain with Universidad Europea de Valencia. This university has developed an online interactive adventure video game-type website, where students were given the task of freely choosing the unit and learning activity to be gamified at their convenience (Sánchez-Mena et al., 2017). It can be easily linked to several knowledge areas. One of them is entrepreneurship due to decision-making being present daily. Indeed, the importance of analyzing the characteristics and perceptions of the users of both, teacher and student is valuable due to the perceptions that the users may have based on their daily basis. The main objective of applying serious games in higher education is to involve students in complex problem scenarios simulating real-world situations. Learners are challenged to develop relevant knowledge representations, and the associated reasoning and problem-solving strategies help them to improve decision-making (Westera et al., 2008). The simulation helps to analyze the player, profile, or student based on the decisions that have been taken.

Nowadays, the world is mediated through Information and Communication Technologies (ICT) as day by day more population has access to the internet. ICT is an essential field of study with a tremendously fast and competitive evolution. As a complementary tool of the ICT, the Technology Acceptance Model (TAM) is proposed, which considers external variables that have a relationship and that influence the acceptance of different technologies. The TAM model has developed three extensions over the years, TAM, TAM 2, and TAM 3. The two main characteristics on which the original model is based are “perceived usefulness” and “perceived ease of use” (Cabero Almenara et al., 2016; Dele-Ajayi et al., 2019).

Throughout the years, the Technology Acceptance Model (TAM) has been used in many fields and studies; for that reason, it is not surprising that this model has been applied in serious games. Several serious game studies only have focused on the original variables of the TAM model. The results of these studies showed that “perceived usefulness” has an impact on attitude toward educational games (Cheng, 2015; Cheon et al., 2015; Martí-Parreño et al., s. f.; Sánchez-Mena et al., 2017), and also on behavioural intention to use (Dele-Ajayi et al., 2019; Yusoff et al., 2010). Other studies have implemented new variables such as perceived enjoyment, perceived playfulness, learner control, transfer of skills, and others. Regarding these studies, results showed that “perceived enjoyment” influences “perceived usefulness” (Camilleri & Camilleri, 2019; Cheon et al., 2015).

1.1 Objectives

The following research questions were formulated considering two points of view: Teachers and students.

Considering the teacher's point of view: i) **Q1:** To what extent does a teacher of an entrepreneurship module believe that using a serious Video Game will support them in carrying out tasks at work?; ii) **Q2:** What are the variables that affect or improve the behavioural intention of using a serious video game in a teacher in teaching entrepreneurship?; iii) **Q3:** What is the degree of enjoyment perceived by a university professor that teaches entrepreneurship when using a serious simulation video game?; iv) **Q4:** What are the factors of acceptance and use of the technologies applied by a teacher when using a serious entrepreneurial video game?

Considering the student's point of view: i) **Q5:** To what extent does a student of an entrepreneurship module believe that using a serious Video Game will support them in completing tasks at work?; **Q6:** What are the variables that affect or improve the behavioural intention of using a serious video game in a student learning entrepreneurship?; iii) **Q7:** What is the degree of enjoyment perceived by a university student of the entrepreneurship course when using a serious simulation video game?; iv) **Q8:** What are the factors of acceptance and use of the technologies applied by a student when using a serious entrepreneurial video game?

For the analysis of this article, a term to highlight its importance is lexical analysis, which consists of data analysis based on technological tools. Another relevant topic of analysis is textometry, in which the corpus is segmented into parts according to the size of the words, which speeds up the research process. Although it depends on the program

that is being used, the searches that establish patterns are defined. In the same way, textometry provides analysis and context to the study in the most efficient way, which eliminates words with low and high frequency within the corpus. On the other hand, there is a software called Iramuteq that enables the statistical analysis of tables and the textual corpus. It helps the information to be presented in a simple, clear, and accessible way. Without a doubt, Iramuteq is beneficial for the area of social sciences and humanities.

The study is structured as follows: Section 2 provides the state of the art of related works with the acceptance considerations of the use of serious games in learning. Section 3 presents the PRISMA methodology and the research design. PRISMA was used to guide the systematic literature review for the years 1980 and 2021. Section 4 sets out the findings that arose from the analysis and discusses them. Finally, conclusions addressing the implications of the findings and possible directions for future research are given in Section 5.

2. Literature Review

The origins of TAM appear in the theory of reasoned action (Ajzen & Fishbein, 1969) and other subsequent developments such as the Theory of Planned Behavior (Schifter & Ajzen, 1985), the Model of Attitude-behavior Processes (Fazio et al., 1989), and the Theory of Trying (Bagozzi et al., 1992). The TAM model appears in contexts regarding the adoption of technologies for online shopping (Bruner & Kumar, 2005; Mallat et al., 2009) and the study of the influence of trust and enjoyment (Ha & Stoel, 2009). This research investigates the usage of different methodological tools for training. In a recent study, Arias et al. (2014) analyzed the intention to use an e-learning by university students with the TAM model. Confirming the explicative capacity of the model, they conclude that students prefer on-site training using a virtual tool to virtual training on its own [20].

According to Verkuyl et al. (2016) two principal variables identified in the original TAM model are “perceived usefulness” and “perceived ease of use”. These variables were identified as likely to play a major role in users' acceptance or uptake of a particular technology. While Davis and his colleagues modified the model and identified several other variables that influence acceptance, the team decided to focus the usability test on the two key original TAM variables (Davis, 1989). Perceived ease of use is defined in this study as the degree to which a person finds a particular technology easy or simple to use, and Perceived usefulness is defined by Davis (1989) as “the degree to which a person believes that using a particular system would enhance his or her job performance.” With the TAM model as a framework, we followed a two-stage usability testing process developed and used in earlier studies (Verkuyl et al., 2016).

The original TAM model was highly criticized; for that reason, the first extension of the model, TAM2, was developed to add more factors that influence the acceptance of technology (Venkatesh & Davis, 2000). Therefore, TAM2 considers the external and social influence by adding five factors (subjective norm, image, job relevance, output quality, result demonstrability, experience and voluntariness), which should explain the perceived usefulness and intention to use (Rondan-Cataluña et al., 2015). Additionally, TAM3 (Venkatesh & Bala, 2008) was elaborated, unifying the two previous TAM models and adding six factors (computer self-efficacy, perceptions of external control, computer anxiety, computer playfulness, perceived enjoyment, objective usability) to explain what influences the perceived ease of use (Lai et al., 2010).

Gamification is an application of game-based mechanics or elements (point-based system, competition with others and game rules), game thinking and aesthetics to engage people, motivate action, promote learning, enable decisions, and solve problems in a simulated environment. Gamification essentially involves the usage of a variety of game elements such as badges, levels, points, challenges, leader boards or even rewards in a non-game environment; it can also be used for business objectives (Deterding et al., s. f.). Learner-centred environments tend to be more fun and appealing. These games have been found to demonstrate a strong correlation with learning outcomes (Ebner & Holzinger, 2007; Prensky, 2010). The whole purpose of gamification is to support learners to move from point A to point B in their lives—be it for functional or behavioural development, societal development or even marketing engagements (Jain & Dutta, 2019). Based on multiple theoretical pillars, Jain and Dutta (2019) propose a gamification conceptual model for millennials that allows millennials to control what they learn, when, where, and how they learn. The needs for instant gratification, success and recognition at the workplace are met by tools like gamification, a competitive leaderboard, social learning, and quick feedback mechanisms incorporated within the gamified platform.

3. Methods

The stages of this systematic literature review include i) a definition of the key research questions and objectives; ii) the identification of published qualitative studies; iii) the identification of published quantitative studies; iv) the exposition of a selection of studies that meet the inclusion criteria; v) the extraction and critical review of evidence and data; and vi) the categorization, synthesis, and diffusion of the results.

For this work, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was considered, as suggested by Bueno et al. (Bueno et al., 2021). This method is widely used in the fields of Health, Education, Business Management, Engineering, and others. In Fig. 1, we expose the application of the PRISMA method, considering all the suggested steps. In identification phase, the following scientific electronic databases were considered: i) IEEE; ii) Web of Science; iii) ACM; iv) SAGE; v) Scopus, and vi) Science Direct.

Considering the operators AND, OR, Parenthesis, quotes and “*”, the present study defined the following search string: ((TAM OR "Technology Acceptance Model") AND (*games OR simulator OR gamification) AND (learning OR university OR academy)). Both the AND operator and the OR operator were used to connect more than two search terms to obtain more precise results. The OR operator is used to identify at least one of the search terms in the returned documents, and the expression AND allows to find documents that contain all the search terms. Additionally, the symbol “*” was especially helpful in identifying terminological variations, representing zero or more characters at the end or in the middle of a search word. Parentheses are used to include multiple concepts in the same search.

Iramuteq is a powerful tool that consists of software that analyzes texts. In this case, it is used to place the abstracts of the 24 articles that are related to the proposed topic (Bueno et al., 2021). This software is important and relevant because it allows textometric analysis to be carried out, in addition, it is applied in several fields and helps to carry out a clear and concise analysis of the information collected. It is important to establish that this research takes into consideration several points such as lexometry, clusters and lemmatization.

3.1 Lemmatization

Various mechanisms of data collection have been developed over the past time with the objective of assisting users in retrieving information from a very long volume of articles. Lemmatization is a type of data collector mechanism. Lemmatization is composed of lemmas. According to Ozturkmenoglu and Alpkocak (2012) a lemma is: “simply the "dictionary form" of a word, and lemmatization is the process of determining the lemma for a given word where different inflected forms of a word can be analyzed as a single item”. Also, a study carried out by the same previous authors mentioned in 2012 concluded that the performance of information retrieval was better when the maximum length of lemmas was used; therefore, it is more effective. Lemmatization uses vocabulary and morphological analysis of words and tries to remove inflectional endings, therefore returning words to their dictionary form. Also, analyze if words are used as verbs or nouns. Indeed, Lemmatization helps to match synonyms by the use of a thesaurus, for example, it searches for the synonym of “hot”, and the result gives the word “warm” as well (Balakrishnan & Lloyd-Yemoh, 2014).

3.2 Application in textometric analysis

A lexicographic analysis must be carried out to have an interpretation of texts. This kind of textometric analysis is held by Iramuteq software, which uses statistics, dimensions, and lemmatization. The usage of lemmatization is applied to obtain preliminary information with the pursuit of replacing each word with its canonical and standard form or its root. Additionally, shows the frequency of the usage of active and supplementary words. Furthermore, some statistics are linked and used with the usage of lemmatizations, such as chi-square to formulate the graphic of the distribution of clusters (Bueno et al., 2021; Lemaire, 2008).

3.3 Limitations

The process of lemmatization also has limitations in the case of automatic extraction of semantic information, that is, when the context of the appearance of words is used. One of the identified limitations of this procedure is that the disadvantages of lemmatization come from the loss of information resulting from the replacement of a word by its lemma; the author hypothesizes that this loss of information is prejudicial to the algorithms which use the context of the words given in context since the latter is not necessarily the same according to the form of the words. Although, the results depend on the language studied due to its own language characteristics. Therefore, the process of the study

must be carefully carried out with the words found in the corpus, which have to be considered according to their context (Lemaire, 2008).

4. Data Collection

The results of data collection performed using PRISMA method are exposed in Figure 1

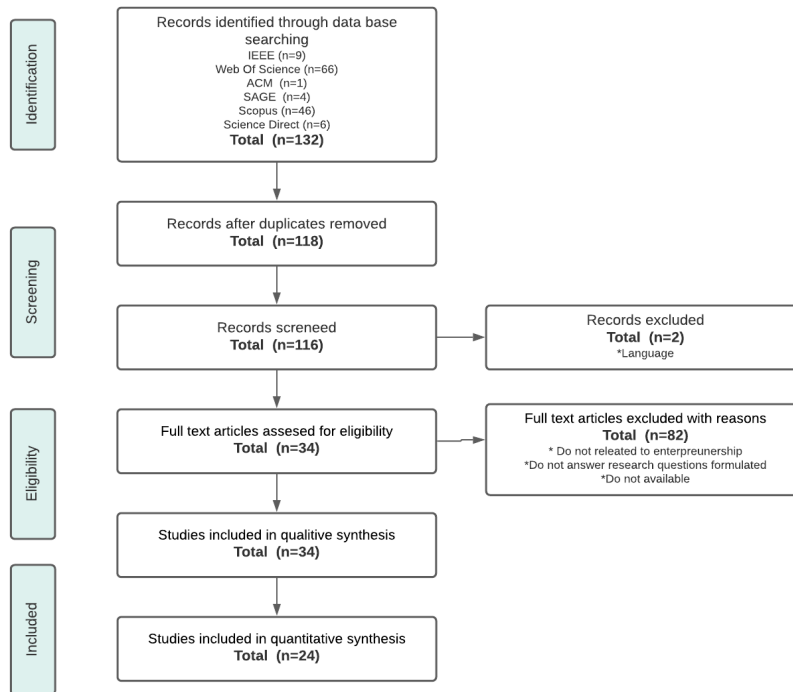


Figure 1. PRISMA application

The time interval considered was from 1980 to 2021 (ended on October 27, 2021). Only works were written in English, Spanish and Portuguese were considered as the main languages. After completing these searches, 132 manuscripts were identified in total. With the “*” symbol, serious games, video games, arcade games, and simulation games were included in the search. To these expressions, the words gamification and simulation were added. These terms appear to influence the search since they are seen as synonyms or words related to video games.

5. Results and Discussion

The following section shows the obtained results. These results are set out in two sections. First, section 5.1 exposes a general view of analyzed studies. Then, section 5.2 sets out and discusses the results in detail in table 1.

Table 1. Literature review summary

Concept	Total number
Manuscripts found	132
Manuscripts without duplicates	118
Articles assessed for eligibility	34
Quantitative studies	24

5.1 Text analysis section

The text analysis was performed with the open-source software Iramuteq version 07 alpha 2. This software facilitates the interpretation of texts through lexical analysis. The analysis was structured in two subsections: i) lexicographic

analysis, which consists of a cluster analysis using the Reinert method, and ii) similarity analysis. The results are given below.

5.1.1. Lexicographic analysis

For this analysis, the titles, keywords, and abstracts of 24 scientific papers were considered and obtained from the PRISMA method application. The application of this lexicometry analysis provides the starting point for the systematic review, identifying the initial data for the rest of the analysis. Hence, a lemmatization process was applied to obtain these preliminary results, shown in table 2.

Table 2: Preliminary analysis after lemmatization

Concept	Total number	
Number of occurrences	4753	
Number of lexical forms (words)	911	
Number of hapax legomenon	409	8,61% of occurrences 44.90% of forms
Average occurrences per text	198.04	

5.2 Detailed Results

To perform the cluster analysis, a type of hierarchical classification was applied, as presented in the following figure 2. Each one has some percentage values inside. Followed by this, there is also a subdivision of groups with their respective representative words. On the other hand, a factorial correspondence analysis was also used in which it is possible to observe the words that are repeated the most, reflected in a plane divided by colours that represent the different clusters. The figures (2-4) are of great help for analysis because they summarize the information collected from the articles and also how the clusters are related.

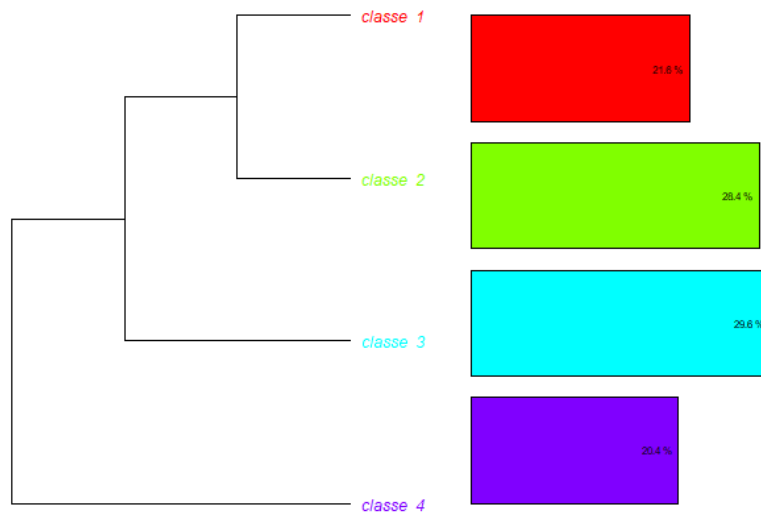


Figure 2. Dendrogram. Cluster analysis. Lexical Clusters

5.2.1. Cluster 1: Emotions, social influence, and gratifications

According to Wu et al. (2010), the uses and gratifications (U&G) is an approach that originated in the 1940s as a reaction to traditional mass communication research emphasizing the use of media to gratify users' various needs and wants, emanating from the individual's social environment and serving as motivation for using media. In the wide spectrum of the word, gratification refers to the extent to which the players' motivations are satisfied. Uses and

Gratifications theory is a framework for explaining user motives for particular media (Gallego et al., 2016). Li et al (2015) pointed out that gratifications include: i) hedonic gratification, ii) utilitarian gratification and iii) social gratification, and explain that social interaction is a large part of playing online games and provides social gratification for players. Finally, they concluded that gratification affects his or her continuance intention to play a game, whereas Wei and Lu (2014) explain that enjoyment, interaction with others and time flexibility are the main reasons for maintaining a player motivated to continue playing.

Social influence is an important factor to consider. As Unterfrauner et al. expose (2020), social inequalities become an important factor that will be considered in a video game because it is a form to mitigate marginalization. On the one hand, as Gallego et al. (2016) exposes, virtual social worlds (VSWs) are increasingly being used in education. On the other hand, social engagement is of great interest in many games, particularly online games that claim Web 2.0 status, like Facebook games which invite friends to play a part in their gaming network producing an effect called “social engagement loops”. Particularly in education, gamification presents numerous obstacles, which can be summarized as context and dilution (DuBravac, 2012).

Context is equivalent to the idea that gamification of education lends itself more readily to online, distance, and independent study courses, and dilution refers to the idea that gamification distracts learners from what is really at stake. One typical case of dilution is the fact that students experience fatigue from the peripheral elements and fail to engage in the target skills (DuBravac, 2012). Emotions are correlated with satisfaction, learning and success in the serious game (A. L. Brooks & Brooks, 2020). Mechanics and motivational factors can be influential in impacting human emotions in playing a game and reaching a state of ‘Flow’ (Csikszentmihalyi, 2004) where immersion is total (A. L. Brooks & Brooks, 2020). Emotion applied in cognitive styles can help to increase students’ learning performance (Huang et al., 2016).

5.2.2. Cluster 2: Structural equations

Structural equation modelling (SEM) is a technique suitable for highly complex predictive models (Zhang et al., 2008). Considering the TAM model, the effect of perceived usefulness on attitude is significant, and attitude directly influences the intention to use. In other words, the teacher's perception of the usefulness of serious video games, the better the teachers’ attitude towards serious video games (Figure 3). The age variable is independent of how teachers’ perceived usefulness and perceived ease of use of serious video games affect their attitude towards serious video games (Sánchez-Mena et al., 2017).

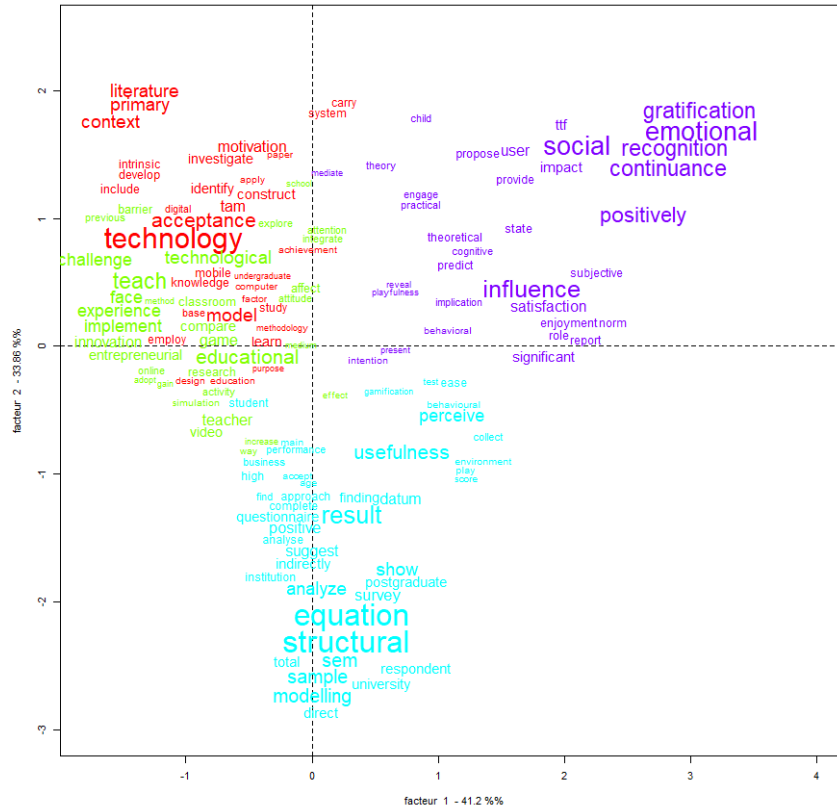


Figure 3. Factorial correspondence analysis (FCA)

5.2.3. Cluster 3: Educational challenges with technology

This is the most important and biggest cluster, representing 29,6% of the total of hapax. Dimitriadou et al. (2021) suggest that serious game design and development can be improved by nurturing the diversity of ideas and adopting creative design and development methodologies, and its implementation can be improved by devising effective administrative and attitudinal strategies and incorporating a diversity of ideas into target curricula. Algayres et al. (2021) mention that flipped classroom is a strategy that could be deployed in an educational context, where games would pit students against a variety of scenarios meant to reflect real-life business challenges and practices, and also have flexible gaming structures or gamification that allow playful learning in a variety of subject, usually used off-class or at the beginning of the class. Another contribution is given by Noemí and Máximo (2014), who believe that the multi-platform capability given by HTML 5 and Unity is one of the main aspects to consider in a video game, but point out that tutoring in serious video games is the key. Three-dimensional technologies can be applied to student learning (Lin & Pryor, 2020).

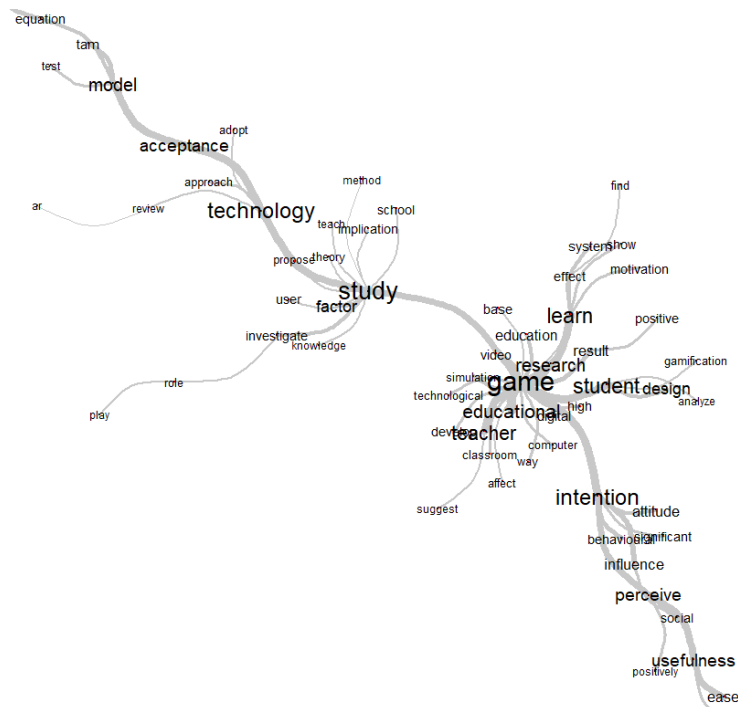


Figure 4. Similarity analysis representation

One of the most important challenges in education was identified during the Covid 19 pandemic when educational institutions had to switch to remote learning (Figure 4). To solve this problem, Recke and Perna (2021) propose the use of a framework for designing and implementing narratively driven learning experiences for embodied, remote, or blended learning scenarios. As argued by Zhu et al. (2021), during this time of the pandemic, students had to overcome challenges such as a lack of face-to-face interaction with teachers, reaction time, and traditional classroom socialization. The following scenarios are identified by Zhu et al. (2021), which are objects of study for design and to propose solutions: i) take exercise class; ii) give online learning feedback; iii) conduct teamwork; iv) take online examinations; and v) study in a dormitory. From this, they present the framework of future educational product design, including i) avoiding disturbances, ii) ensuring equipment; iii) promoting learning; iv) creating a learning atmosphere; v) improving learning efficiency; vi) reasonable planning; and v) apply a proper pressure for learning.

4.2.4. Cluster 4: Technology acceptance model

TAM, first proposed in 1989 (Zhang et al., 2008), was conceived to explain and predict the individual's acceptance of information technology. According to the technology acceptance model (TAM), two factors, namely Perceived Ease of Use and Perceived Usefulness (Chen & Chen, 2011) associated with video games, are assumed to affect players' acceptance attitude toward the video game technology and lead to gamers' adoption intention. Serious game experiences drive personal change and transformation by generating an attitude of acceptance of the challenge, motivation to achieve, and constant innovation through participant commitments (Ahmed & Sutton, 2017).

To evaluate a video game, Tlili et al. (Tlili et al., 2016) proposed a Likert scale questionnaire based on TAM, which aims to evaluate the learner's satisfaction after using the game. The questionnaire contains 13 statements and covers the four variables of TAM, which are: i) Ease of use, which defines the degree to which learners find the game easy to use and free of effort; ii) Usefulness, which defines the degree to which learners think that the game will enhance their level of knowledge while learning computer architecture; and iii) Attitude towards using the game, which defines the degree to which learners report a favourable and positive attitude towards the game after using it and, iv) Intention to use the system which defines the degree to which learners are willing to use the game again in the future to learn computer architecture. On the other hand, Varela (Yong Varela, 2004) uses a questionnaire considering 37 questions divided into 3 sections: i) context of the analysis; ii) availability of information technology in the studied context; iii) demographic data from the studied group. After applying the TAM model over open source software, Gallego et al. (Dolores Gallego et al., 2015) findings provide evidence that in an educational environment based on technology,

trainers' support is an important factor that has an influence positively and directly on user behaviour. Also finds that factors related to demographic dimensions directly affect acceptance of OSS solutions.

6. Conclusion

Serious video game developers and trainers can take the required measures to predict or promote user technology acceptance more effectively and efficiently. It is important to point out that the key factor in serious video games is tutoring. After the literary review, we believe that the use of a serious video game for entrepreneurship learning will contribute to the academic training and learning outcomes of university students, an aspect that will allow them to glimpse into practice what they have learned in theory. The players' satisfaction considering the challenges and rewards found at the end of the effort motivates them to get involved with the video game. It is important to note that feedback must always be present since gaining or losing points in the face of situations that arise will cause more or less interest in different levels of the platform.

According to the study made, it is shown that an entrepreneurship professor believes that Learner-centered environments tend to be more fun and appealing. Therefore, video games have been found to demonstrate a strong correlation with learning outcomes. It is considered that an entrepreneurship student prefers to combine face-to-face training with a virtual tool. This hybrid type of education seems to be a good way to help them improve their training process. Moreover, in this study, we have found that entrepreneurship college students that combine class activity with online games experience social gratification, so their intention to continue playing increases. Proving that enjoyment, interaction with others and time flexibility are the main reasons to keep a player motivated, which can lead to continuing playing and therefore increase their learning process outcomes. In addition, it is important to consider that remote studies due to Covid-19 have changed the way students learn. This experience gives educators and education leaders new and innovative ways to introduce technology and gamification in the learning-teaching process. It also gives a great opportunity to implement new strategies to improve the student experience and to discover new and exciting ways of learning, especially with the use of gamification and video games.

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