Acceptance of Serious Games to Develop Digital Competencies in Higher Education

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Abstract: Serious games are the focus of the current research agenda. They show promise for allowing students to learn and practice skills. In fewer studies, they are used for the development of academic competencies. Therefore, it is of interest to deepen the research on the benefits of serious games in academic education and training. This article presents a study using serious games aimed at higher education academics' training for the development of digital competencies. The study was carried out with 56 academics, using the serious game called AstroCódigo. The study analyzed the level of acceptance of serious games using the TAM model and what factors the academics believe affect this acceptance. It is important to know possible barriers that affect the development of actions oriented to the formation of academic competencies through serious games, which can also affect the adoption of games as a resource for teaching situations. None of prior studies have focused on analyzing the technological acceptance of serious games used for the development of academic competencies. The results of this research indicate that participants believe that using serious games can be beneficial to drive digital competencies. However, there are aspects such as the highest academic qualification, work experience, professional development, perceived usefulness, ease of use, and fear of change associated with age rank which can play a negative role in the use and acceptance of digital technologies by academics, particularly serious games. These results may be a clue to the barriers linked to the fact that most of the participants in this study do not use serious games in their classes or for their digital skills training. Additionally, the possibility to try and fail and the increased level of challenges proposed in the serious games, related to enjoyment, were valued by academics, during the sessions with AstroCódigo. These findings open the door to organize strategies for academic training in digital competencies within higher education institutions. They can also impact the design decisions of new serious games.

Keywords: serious games, digital competencies, academics training, technology acceptance model, higher education

1. Introduction

The fast progress of Information and Communication Technologies (ICTs) has caused the proliferation of new tools and applications that help and support people in their everyday activities, regardless of their occupations (Gisbert and Lázaro, 2014). Serious games and games in general have gained popularity in the industrial sector, health, business, government, and education, where they have been used with different purposes, going from entertainment to simulation and training (Vlachopoulos and Makri, 2017; Leonard et al., 2018; Mittal et al., 2021; van der Lubbe et al., 2021).

In the educational context, and specifically, higher education, serious games have been used for training and/or acquiring skills and competencies in various knowledge areas, combining fun, entertainment and learning, mainly with students (Boyle, Connolly, and Hainey, 2011; Chua and Balkunje, 2012; Girard, Ecalle and Magnan, 2013; Sung and Hwang, 2013; Vlachopoulos and Makri, 2017). Serious games are a way to teach digital competencies in a motivating manner as they help to reduce the frustration and stress level of academics by combining them with entertainment. They allow for immediate and frequent feedback, as well as visualizing progress in a step-by-step manner (e.g., through badges or scores), aspects that characterize them and make them different from other technologies (Sánchez-Mena, Martí-Parreño, and Aldás-Manzano, 2017; Krath, Schürmann, and von Korflesch, 2021; Min, Min, and Kim, 2021; Kroustalli and Xinogalos, 2021). However, only limited research (Annetta et al., 2014: Nousiainen et al., 2018; Sánchez, 2013; Tondeur et al., 2018) has been dedicated to using serious games for the development of digital competencies for academics in Higher Education Institutions (HEI) (Sánchez, 2013).

This article focuses on the analysis of the development of digital competencies for academics of HEI using serious games. The research also proposes an analysis of the acceptance of this type of technology, as no previous studies revised focus on this type of analysis. Developing a technology acceptance analysis makes it possible to

know the perceived usefulness of academics in relation to serious games. At the same time, it allows to know their beliefs of the ease of use and other variables that will affect their adoption and use (Teo, 2009; Sampiero and Barragán, 2018). There is a need to investigate possible barriers which may affect the development of actions, by educational institutions, aimed at the formation of academic competencies through serious games, which can also affect the adoption of games by academics as a resource for teaching situations. Considering this, a study was conducted with 56 participating academics, using the serious game AstroCódigo for the development of digital competencies. The study sought to investigate the technological acceptance of the game for the development of these competencies, using the Technology Acceptance Model (TAM) (Davis, 1989; Teo, 2009). During the study, a methodology was used to guide the decisions related to the integration of serious games for an educational situation. Thus, the research carried out allowed the authors to understand the barriers and potential that can influence the training of academics in digital competencies through serious games. Also, to analyze what other factors impact the adoption of serious games as a teaching resource for academics themselves, since, these types of games enhance motivation (Bozkurt and Durak, 2018; Tang et al., 2019; Kiron et al., 2020), improve student involvement in educational activities (Ekici, 2021; Mullen, Milechin, and Milechin, 2021), and contribute to their learning experience (Guillén-Nieto and Aleson-Carbonell, 2012; Krath et al., 2021), among other benefits.

Going forward, this work is organized as follows: Section 2 discusses the concept of technology-related competencies (digital competencies), technology acceptance models, and it defines what a serious game is. Section 3 describes the research methodology used; Section 4 presents in detail the methodology proposed for integrating and evaluating the use of serious games. Then, Section 5 describes the results of a study carried out using the methodology proposed with a group of 56 academics at the Atlantic Branch of the University of Costa Rica. Section 6 includes the conclusions and highlights future lines of work.

2. Literature Review and Theoretical Background

This section presents, on the one hand, the importance of serious games for the educational field and, in particular, for the training of digital competencies. On the other hand, it describes the contributions of the TAM model, linked to discovering how a technology can be adopted or not, identifying the factors that could influence such acceptance, in this particular case the focus is on the acceptance of serious games.

In this work, the following definition is used: digital competencies are understood as a construct of pedagogical knowledge mediated by ICTs, and they include cognitive and instruction tools that boost knowledge acquisition and learning (Nousiainen et al., 2018). According to Choi, Cristol and Gimbert (2018), academics need ongoing training to acquire new knowledge and skills in digital technologies that will allow them to facilitate teaching and learning processes in accordance with the educational demands of the current society.

On the other hand, the correct use and integration of ICTs in educational processes require faculty to be technology- and pedagogy-wise competent with technological, pedagogical, and disciplinary skills (Calvo-Morata et al., 2019; Dalal, Archambault and Shelton, 2017; Scherer, Siddiq and Tondeur, 2019). Having digital competencies is a necessity of these times regarding the increase of careers in hybrid modalities that make it possible to meet the needs of lifelong learning; the contribution of technologies to enrich the educational scenario, and situations such as the Covid-19 pandemic that show the need for training in digital competencies of academics and students (Pedró, 2020).

2.1 Serious Games

The concept of serious games has been defined by a wide variety of researchers (Sandí and Sanz, 2020; Calabor, Mora and Moya, 2017; López et al., 2019; Michael and Chen, 2006; Pellas, 2014). The term serious games was first introduced in 1970 by Abt (1970), who focused on researching the possibilities these games offered in an educational, entertaining, and social context. His aim was to identify the possibilities to use serious games for instruction, training, education, fulfillment and/or as a source of enjoyment and motivation and to develop new skills and knowledge (Abt, 1970).

Michael and Chen (2006) state that the purpose of serious games is not only entertainment, enjoyment, or straight fun, but that they essentially have an explicit and carefully thought-out educational purpose. In this regard, Archuby, Sanz, and Pesado (2019) reviewed the concept and presented a game called Desafiate for students' self-evaluation. Serious games have been used in and applied to different knowledge areas for

educational purposes and to drive significant changes in attitudes and behavior in people, to help them acquire and develop skills and competencies that will produce meaningful knowledge for adequate performance in their everyday chores (Muñoz et al., 2011).

According to different systematic literature reviews (Bozkurt and Durak, 2018; Dimitriadou et al., 2021; Hassan, Pinkwart, and Shafi, 2021; Krath et al., 2021; Min et al., 2021), it is evident that the use and integration of serious games in training processes, present the following benefits: they allow changes in attitude, behavior, emotions recognition and production, as well as enhancing thinking, reasoning, motivation, communication and the promotion of digital competencies among students and academics. For the purposes of this study, a serious game is therefore defined as one characterized by having an approach that goes beyond entertainment or fun, that is, it can be used to enhance different areas of knowledge, to promote attitude or behavior changes, to generate emotions, to address the acquisition of skills and competencies, collaboration and interactivity, among others.

In order to investigate backgrounds of serious games that have been used for the development of competencies, a specific study of different articles was conducted. Among the main cases studied some are mentioned in the following paragraphs.

A research project, related to what kind of competencies academics need in using game-based pedagogy (Nousiainen et al., 2018), proposes the following conceptual framework: “using educational games, using entertainment games, learning by making games, and using game elements in non-game contexts (i.e., gamification)” (Nousiainen et al., 2018, p.86). Considering this framework, the study proposed here focuses on using educational games for academics’ digital competencies training.

There are some researches who analyzed the use of serious games, considering different variables. For example, the one that proposes the use of “Science Training Immersive Modules for University Learning Around Teacher Education (STIMULATE), which is a Serious Educational Game designed to advance science teacher preparation and development” (Annetta et al., 2014, p.61). This work analyzed the “usability and effectiveness of STIMULATE’s initial build on 31 preservice teachers” (Annetta et al., 2014, p.61). The results suggest positive learning gains from the preservice science teachers in science preparation and development. Also, the proposal of Cisco Packet Tracer, that created a simulator type game aimed at training and empowering a network of configuration skills for all audiences (academics, students, technicians, among others) (Janitor, Jakab, and Kniewald, 2010). Later, the simulator was used to develop a plugin for Moodle called “PTActivity”. Petcu et al. (2013) indicate that the integration of the PTActivity module offers the possibility of improving the technological skills training process, the collaborative work and the learning experience for academics and students. The serious game, called NoviCraft, was developed with the objective of promoting, through training, the acquisition/formation of pedagogical and technological competencies in academics and students (Häkkinen et al., 2012). NoviCraft has been used in different universities in Finland and the United Kingdom. As a result, it was found out that the game allows the improvement of work skills such as communication, collaboration, technology, management, and leadership (Romero, Usart and Ott, 2015). NoviCraft also boosts motivation, interest, and commitment on the part of the players (Juzeleniene et al., 2014). In France, the French Institute of Education developed the serious game Tamagocours with the purpose of training academics in technological-pedagogical skills in higher education (Sanchez, 2017). Specifically, Tamagocours allows to enhance the skills and competencies required to articulate the integration of digital technologies and the Internet in the training processes (Sanchez, 2013). In total 81 participants used the game to prepare for the certification called Informatics and Internet Certificate for Teachers. The result was that academics developed different game strategies: try and failure, controlled choice, and collaborative game (Sanchez and Emin-Martínez, 2014; Sanchez, Emin-Martínez and Mandran, 2015).

Up to this point, the antecedents in which serious games are used have been described and/or analyzed to enhance digital competencies in academics and/or with students. None of these studies have focused on analyzing the technological acceptance of serious games used for this purpose. In this sense, the contribution of this research is to provide an analysis from the academics' belief in relation to the acceptance of serious games for digital competencies training, and to analyze their beliefs about the factors that can impact the use of this type of games, and the value relevance of these games. Particularly, this project focuses on HEI academics to determine what barriers are found to deepen the formation of digital skills for academics, and that they in turn adopt the serious games in their teaching contexts.

2.2 Technology Acceptance Model (TAM)

In this subsection, the TAM is discussed in more detail. Some of the existing models that allow measuring the acceptance level of digital technologies by users were studied (Ruiz, Pardo, and San Martín, 2010; Hernández-Arellano, 2016; Dell'Olio et al., 2018; Burić and Kim, 2020; Fakhari and Rima, 2021; Yin and Huang, 2021). One of these models was TAM by (Davis, 1989) and its variants: TAM2 (Venkatesh and Davis, 2000) and TAM3 (Venkatesh and Bala, 2008). The TAM model highlights two relevant aspects in the intention of use for any given technology – perceived usefulness and perceived ease of use (Scherer et al., 2019). The TAM2 model, on the other hand, focuses on expanding and inquiring about the constructs that can have some sort of influence in relation to perceived usefulness (Venkatesh and Davis, 2000). Finally, the TAM3 model focuses on the aspects that can affect perceived ease of use (Sampiero and Barragán, 2018).

Various studies have measured technological acceptance, both among students and faculty (Bachtiar, Rachmadi and Pradana, 2014; Liqin and Mengmeng, 2016). For our case in particular, experiences directly related to technological acceptance are of interest. Table 1 details some relevant previous experiences using the TAM model to analyze technological acceptance, particularly in academic scenarios.

Table 1: Examples of previous projects using TAM to measure technological acceptance

Country, Researcher/s	Objective
Taiwan (Wang and Wang, 2009)	Measuring academics' acceptance level when using web-based learning systems.
Singapore (Teo, 2009)	Studying academics-to-be attitudes towards the use of technology in education.
United States of America (Chen, 2010)	Developing a model that appropriately represents the factors affecting the use of technological resources by academics in training.
Malta (Camilleri and Montebello, 2011)	Measuring academics' technological acceptance in relation to the use of *Virtual Worlds* in their pedagogical practices.
Turkey (Acarli and Sağlam, 2015)	Measuring the intentions of a group of academics in relation to the use of social media as part of their academic activities.
Spain (Sánchez-Prieto, Olmos-Migueláñez and García-Peñalvo, 2015a; 2015b)	Assessing the behavior and the behavioral intention to use mobile learning, specifically, the use of mobile technologies in classes by academics taking their initial courses towards a Bachelor of Arts degree in Primary Education at the University of Salamanca.
England (Rienties et al., 2016)	Examining the interaction of academics when faced with using a new *Virtual Learning Environment*, aimed at identifying and perceiving how support and technological acceptance affect complying with tasks (perceived and real).
China (Quadir and Zhou, 2021, p1)	Investigating how students "perceived the effect of the Tencent Meeting system features on the two main determinants of the TAM model, namely perceived ease of use (PEOU) and perceived usefulness (PU). The study further analyzed the effects of these two determinants on learning performance".

The examples of previous projects shown in Table 1 correspond to instances where the TAM model was used to measure, evaluate and/or examine the acceptance level of digital technologies by academic institutions in various countries. They highlight the value of this model. However, there are few studies that show the use of TAM to evaluate the acceptance of serious games. In this sense, researchers López et al. (2021) carried out a study in Spain to analyze the intention to use the serious game Lego© Serious Play© which was aimed at training management skills in higher education students. To achieve the objective of the study, López et al. (2021) adapted the TAM model and the CAN model (Cognitive-Affective-Normative). The result was that the most influential factor in the intention to use serious game was linked to the expected learning performance.

In another study in Spain, Sánchez-Mena et al., (2017), using the TAM model, studied the factors that could influence the intention to use educational video games in the classroom by a group of 312 academics at higher

education level. The result was that the perceived utility directly and positively influences the intention of academics to use educational video games. Likewise, the study allowed to conclude that perceived ease of use indirectly influences the intention of use.

In Greece, Kroustalli and Xinogalos (2021) conducted a study at secondary level and they used the TAM model to determine the acceptance, ease of use and perceived usefulness by students in relation to using the serious game CodeCombat to acquire competencies in programming, and problem solving through Python. As a result, CodeCombat had a positive evaluation in relation to the ease of use, perceived usefulness and attitude towards its use. The results were positive in terms of the use of serious games for general programming.

None of the previous studies used TAM to determine the acceptance of serious games. Therefore, in the current study, the game Astrocódigo was used for the development of digital skills in academics. Other factors that academics perceive may influence the use of these types of games are also investigated. In this way, this study contributes to understanding the barriers and possibilities of serious games perceived by academics for their training in digital skills, as well as their intentions to use them for the integration into their own educational practices.

3. Research Methodology

Research questions were defined to guide the study, focus on the acceptance of serious games by academics and the variables that affect it. This study can later help to work with academics on the barriers that influence the use of this type of games, and in organizing teacher training strategies related to digital competencies in HEI. In addition, it can help to define design guidelines for new serious games oriented to the educational scenario.

The research questions (RQs) used for this study encompassed aspects such as: RQ1. What is the academics' attitude towards digital technologies? RQ2. What is the level of acceptance of the serious game used in the study, and how do the factors like age, gender, highest academic qualification, professional training, and seniority impact on this acceptance according to the beliefs of academics? RQ3. According to TAM's dependent variables, what factors could affect the academics' decision to integrate digital technologies? RQ4. What is the academics' level of interest for exploring, using, and integrating serious games into their educational activities? RQ5. What is the academics' acceptance level for using serious games to enhance their technological skills?

In order to answer the research questions, a study with a set of sessions was carried out with 56 academics (among them 5 directors of the participating institution) from the Atlantic Branch of the University of Costa Rica, Costa Rica, in which quantitative-qualitative data were combined. At the beginning of each session, the objectives were explained to the academics together with the competencies to be worked on and the methodology used to plan the study and some basic aspects of the use of Astrocódigo. Most of the academics worked individually and some worked in pairs. For the analysis of the results, a series of evaluations were carried out considering variables of TAM to measure the technological acceptance and in turn, describe the attitudes of the academics towards the use and acceptance of digital technologies (All, Núñez Castellar and Van Looy, 2016; Sung et al., 2017; Wronowski et al., 2020): (a) Pre-Test: a diagnostic questionnaire, b) Intermediate Evaluation: through a questionnaire about the experience with the serious game and observation of the sessions, and c) Post-Test: an opinion questionnaire and interviews). Also, in order to understand the entry level of the participants, their beliefs about their level of competencies related to the use of internet, social media, cloud computing tools of possible use in education, and the pedagogical use of digital technologies were analyzed (through the Pre-test questionnaire) (Cabero, Sampedro, and Gallego, 2016; Wronowski et al., 2020; Mullins and Cronan, 2021).

Among the 56 participants, 5 directors were interviewed. The interview was applied to the directors to get a more institutional vision related with the topic of study. The purpose was to investigate what related factors administrators consider influence in the use or not, the integration and acceptance of digital technologies by the academics, and particularly of serious games. The interviews were applied at the offices of the administrators, they were recorded in audio and transcribed. The responses were organized and processed by category of analysis and tables were used to synthetize the information.

For the current study, six customized scenarios of the AstroCódigo game (http://www.astrocodigo.com/) were used. AstroCódigo is a serious game where problems are solved algorithmically. The game was designed to help

structure and organize thought and solve problems by creating algorithms. Among its capabilities, it helps develop technological competencies by taking the users (in the current study, the academics) through a journey exploring concepts such as hardware and software and providing the users with problems that have to be solved in a structured manner, promoting algorithmic thought, abstraction capabilities, and using digital technology to plan actions (Bione et al., 2017).

The following section describes the methodology proposed and used for integrating serious games into academics training programs.

4. Methodological Steps for the Development of Sessions with the Academics

In this section, an account of our work methodology is provided, aimed at developing and/or strengthening academics' training in technological competencies through the use of serious games. To guide the selection of which technological skills to focus on, the classification of technological competencies created by the Ministerio de Educación de Chile (2006) and the proposal prepared in Spain by Prendes (2010) and Prendes and Gutiérrez (2013) were considered. This was based on the fact that the classifications presented by these studies were appropriate to the country where the current study was carried out. Figure 1 provides a summary of the sequence of methodological steps followed during the study (Sandí, Sanz, and Lovos 2018).

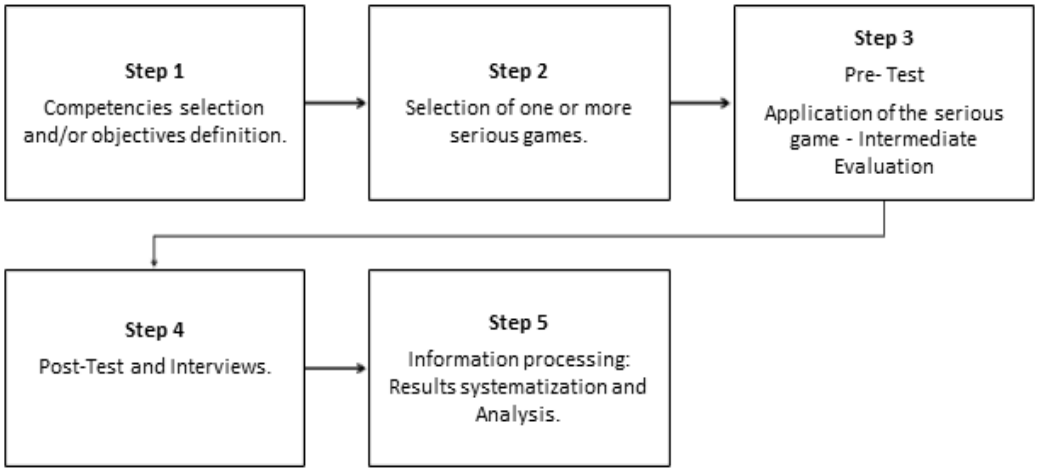

Figure 1: Methodological sequence for serious game integration and evaluation in academics education and training. **Source**: Authors' own compilation.

The following section explains in more detail the results obtained after implementing the steps highlighted in Figure 1 to conduct the study.

4.1 Applying the Methodology

A study using serious games was carried out in an academic training process at the Atlantic Branch of the University of Costa Rica with the following objectives: a) to consider if the methodological strategies proposed are effective, and b) to assist academics to develop technological competencies from serious games integration, analyzing their level of acceptance and determining the factors they believe affect this acceptance. It should be noted that both the study and the results obtained are presented considering the beliefs of the academics in relation to the variables that might affect their own acceptance of digital technologies, these views being important to consider during the process of technological acceptance by academics (Jääskelä, Häkkinen and Rasku-Puttonen, 2017). The findings will assist to determine if the participating academics show a good level of acceptance of the serious games in order to be able to subsequently address any possible barriers that may arise. In addition, the findings can contribute to the design of future serious games oriented to the educational scenario, seeking to break down the barriers encountered, and to their integration in educational processes.

When planning the study with the academics, the methodological steps, proposed in Figure 1, were followed. Table 2 summarizes the main decisions made in each step.

Table 2: Methodological application.

Steps	Activity	Decision
Step 1	Competencies selection and/or objectives definition.	Selecting the competencies to be enhanced - Five competencies matching to the dimension of "teaching" in the profile defined in Spain by Prendes and Gutiérrez (2013) were selected. These are: a) knows new concepts and basic components linked to ICTs, b) designs activities that use ICT resources, c) uses various methodological strategies with ICTs, d) implements educational activities that use ICT resources, and e) participates in ICT-related training activities (Prendes and Gutiérrez, 2013; Hernández, Arévalo, and Gamboa, 2016; Silva et al., 2016).
Step 2	Selection of one or more serious games.	Selecting the game - The serious game AstroCódigo which solves scenarios in an algorithmic and fun way was selected. This game helps developing technological competencies because: a) it asks academics to find out about concepts such as hardware and software (competencies a, b and d, from Step 1); b) it proposes solving the problems in a structured manner, which helps develop the kind of structured thinking required for planning and using digital technology (competencies b, c and e, from Step 1) (Boyle et al., 2011; Giannakos, 2013; Hainey et al., 2016).
Step 3	Pre-test application of the serious game - intermediate evaluation	Pre-test using the game - On-site sessions to use AstroCódigo were carried out with 56 academics from the Atlantic Branch of the University of Costa Rica. These sessions had an approximate duration of 150 minutes each, and there were between 4 to 12 participants in each group. Participation was free and voluntary; participants were from different subject fields. The invitation was sent to all the academics of this branch, but only 56 decided to participate (Chang et al., 2012; Almerich et al., 2016; Qian and Clark, 2016).
Step 4	Post-Test and interviews	Three evaluation stages were used - The participants were asked to answer 3 questionnaires. First, a Pre-Test (diagnostic questionnaire) was used to identify academics' current status concerning their digital competencies and their opinion related to ICT and their opinion and knowledge about serious games. Second, an Intermediate Evaluation was used to analyze how academics accept the serious game, their beliefs of the game, whether acceptance or rejection was observed, and the variables proposed in the TAM model were examined. Third, a Post-Test was used to contrast the evolution of the academics' competencies and beliefs after applying the game (Campos and Lule, 2012; Sung and Hwang, 2013; All et al., 2016; Sung et al., 2017; Winke, 2017). The interviews applied to the 5 directors of the participating institution were done individually.
Step 5	Information processing: Results systematization and Analysis	Processing the information - The information obtained was organized into tables, systematized and analyzed using charts, tables and graphs. Data were analyzed using the SPSS statistical package Then, findings and conclusion reports were prepared (Díaz-Bravo et al., 2013; Hernández, Fernández, and Batista, 2014).

As indicated in Step 3 of Table 2, AstroCódigo was used with six customized scenarios of increased difficulty where academics had to program a virtual robot to recover some pieces of a ship, using instructions to achieve this goal. This was part of the story of the game. AstroCódigo is designed to help structure and organize thought and solve problems by creating algorithms.

In regards to the evaluation, as part of the initial evaluation process, the authors decided to develop an instrument to carry out a previous assessment of participants, with the purpose of defining the entry point and to identify academics' attitude towards technology, prior to the use of the game to visualize the previous approach and the motivation of the participants in relation to digital technologies. For this purpose, a questionnaire with multiple choice and Likert-type questions was used, with previously delimited categories or response options. This instrument was developed from questionnaires available in the literature (Chiou, Lee, and Tsai, 2013; Hwang, Yang, and Wang, 2013; All et al., 2016; Sung et al., 2017).

The initial questionnaire (pre-test) consisted of 55 items: 7 multiple choice, close-ended questions and 48 statements to be rated using a 5-point Likert-type scale. Questions and statements referred to participation in previous training sessions in the HEI (2 statements), Internet competencies, social media and cloud computing (6 statements), pedagogical use of digital technologies (16 statements), attitude towards digital technologies (3

statements), ethical and technological competencies (4 statements), attitudinal competencies and technological acceptance (before the experience with AstroCódigo) (12 statements), beliefs and attitudes in relation to serious games and acquisition of technological competencies (5 statements).

Similarly, the post-test was custom-created for the study and consisted of 35 items: 3 multiple choice, close-ended questions and 32 statements to be rated using a 5-point, Likert-type scale. These statements revolved around attitudinal competencies and technological acceptance, serious games and the acquisition of technological competencies. The statements were aimed at identifying attitudes and technological acceptance (after using AstroCódigo) (12 statements), Perceived Ease of Use (PEU) (5 statements), Perceived Usefulness (PU) (4 statements), behavioral Intention to Use (BIU) (5 statements), Self-Efficacy (SE) (3 statements), and Anxiety (A) (3 statements) when using serious games in general and AstroCódigo in particular. Also, the effect of the process on the acquisition of the desired competencies based on the goals proposed was assessed, two yes-no questions with space for justification were added related to the opinion of using AstroCódigo for digital competencies development and about the interest in developing new training instances of these competencies using serious games. This was based on current literature (Khenissi, Essalmi, and Jemni, 2015; Sánchez-Prieto et al., 2015b).

Questionnaire reliability was measured using Cronbach's alpha (Cronbach, 1951), which has been widely used in educational technology research (Hernández et al., 2014). In the current study, Cronbach's alpha analysis was applied to both questionnaires (pre-test and post-test). Data were analyzed using the SPSS statistical package, and both questionnaires yielded a high reliability index, as shown in Table 3.

Table 3. Reliability of pre-test and post-test.

Test	Cronbach's α	# elements
Pre-test	0.924	55
Post-test	0.886	35

The intermediate evaluation consisted of 21 items (19 single-selection and 2 multiple choice questions). The questionnaire was applied while participants were using AstroCódigo, and photographic, audio and video support, as well as an observation guide. Also, some questions were formulated by the researchers during the sessions in order to deepen the opinion of the participants. This evaluation allowed registering mainly whether academics had achieved any progress in solving scenarios with or without help (Giannakos, 2013; Campos and Lule, 2012; Winke, 2017).

Interviews with the participating directors were semi structured with questions related to the research questions.

It is important to mention that there were no ethical problems or problems at the level of the processes before, during or after the development of the study, because before the application of the different instruments (questionnaires and interviews), the academics and HEI administrative staff knew and previously signed the informed consent form (to be a research subject). The academics authorize the researchers to record the sessions on audio and video, as well as to use and make public the information obtained and the results of the study through reports, sessions to present results and / or publications in journals. The instrument was created by the authors, taking as reference the informed consent form based on Law N ° 9234 "Biomedical Research Regulatory Law" and the "Scientific Ethical Regulation of the Vice-rector for Research of the University of Costa Rica for research involving human beings.

Finally, it should be noted that the instruments (pre-test questionnaire, intermediate evaluation, and post-test questionnaire) were validated with five national and international experts (from Argentina and Costa Rica), who participated as external judges and critically assessed the statements included in all questionnaires to be used and suggested adjustments, they deemed necessary based on the research objectives proposed.

The following section discusses the main results obtained in all three evaluation phases applied to the study.

5. Results and Discussion

This section discusses and presents the results obtained. Results are organized in response to the RQs.

RQ1. What is the academics' attitude towards digital technologies?
The preliminary evaluation (Pre-test) was used to establish the profile of the participants. Also, their opinions in terms of technology integration, and their beliefs related to the variables they think affect digital technology acceptance by academics in general, and about serious games and the acquisition of technological competencies. Additionally, their starting status was analyzed in relation to the competencies that are to be developed.

The pre-test included a specific question to participants: **Have you received previous training in the development of technological competencies?** In general, it was observed that participants had a low level of previous training (M= 4.50 and SD= 1.859). They pointed out that they are rarely trained to acquire technological competencies (see Table 4). For this reason, they mentioned that it would be a good idea to plan actions aimed at creating projects that could offer them more opportunities in relation to access to ongoing training programs in various knowledge areas in general and digital competencies in particular. This coincides with the necessities mentioned in (Choi et al., 2018; Pedró, 2020).

Participants had a very high level in Internet, social media and cloud computing competencies (M= 25.07 and SD= 3.144; see Table 4). They indicated they were proficient users of e-mail, social media, Office packages and use of cloud-based services (like Google Docs, Dropbox, Google Drive). This means that participants have knowledge about these technologies, which could be useful on a pedagogical level. However, they only mentioned using Virtual Teaching and Learning Environments (VTLEs), spreadsheets, word processors, software to create, edit and design electronic presentations, and electronic mail. They stated that they needed training for the pedagogical use of certain digital technology tools (authoring tools, wikis, educational digital games, mobile apps) so as to be aware of their possibilities applied to teaching and developing skills to use them to create innovative pedagogical activities. This coincides with what is indicated in Section 2, where the correct use and integration of ICTs in educational processes require a faculty that is technology- and pedagogy-wise competent; with technological, pedagogical and disciplinary skills (Calvo-Morata et al., 2019; Dalal et al., 2017; Scherer et al., 2019). Participants showed interest in using digital technologies – they believe these benefit classrooms learning and help improve some aspects of teaching quality. Academics' attitude towards digital technologies was good (M= 12.30 and SD= 2.304; in Table 4).

Regarding serious games and the acquisition of technological competencies, participants were very interested (M= 22.33 and SD= 3.533) in incorporating serious games to their practices. They also considered these games as beneficial for their work and for their technological competencies training process. This could indicate that participants have a predisposition to exploring, using and integrating these games into their educational activities, but they are not applying them in their educational practices. It is likely that the lack of a training program in this regard is the reason why they are not yet included. It is therefore also important to know what barriers may affect the development of these programs and the adoption of serious games in their educational practices.

As regards attitudinal competencies and technological acceptance, in the pre-test it was observed that there was a very high belief (M= 51.23 and SD= 7.644) that there are variables that affect technology acceptance, such as, the Perceived Ease of Use (PEU), the Perceived Usefulness (PU) and Behavioral Intention to Use (BIU) associated with enjoying. Seventy-five percent of the participating academics totally agreed that when they perceive a digital tool as easy to use and useful, they feel a greater incentive to use it; while a 16.07% agreed with this statement; the rest of the participants (8.93%) were undecided.

These results match those obtained in theoretical research studies, where TAM proposes precisely these variables as relevant factors that affect the decision to use any given technology. In addition, there are factors that participants believe may affect the acceptance of these types of technologies such as: as academic training, professional training, seniority in the job, age range, and so forth. This is further discussed in RQ2.

RQ2. What is the level of acceptance of the serious game used in the study, and how do the factors like age, gender, highest academic qualification, professional training, and seniority impact on this acceptance according to the beliefs of academics? and RQ3. According to the TAM model dependent variables, what factors could affect the academics' decision to integrate digital technologies?
To answer RQ2 and RQ3, from the initial questionnaire, beliefs of participants in relation to technology and serious games, in particular, were analyzed. This can be seen in Table 4. After carrying out the study, in the post-

test, they were asked about these beliefs again, in order to identify the potential impact on participants after using the serious game.

As regards attitudinal competencies and technological acceptance, there was a slight increase in the mean of the post-test, from 51.23 to 51.75 (post-test: M= 51.75 and SD= 7.166), versus the pre-test in the belief that certain factors affect technological acceptance (like: Highest academic qualification, professional training, seniority in the job). Table 5 summarizes some of the results obtained on a general level when comparing the dimension "attitudinal competencies and technological acceptance" in both questionnaires. It can be seen that there was a slightly change in the belief regarding which factors affect technology acceptance. After using the game, some participants no longer believe that age is a barrier to technology integration (M=3.82 and SD= 1.193), which can be due to an increased confidence in using games regardless of their age. Even though there is a slight variation in the mean, the belief that other variables such as academic training (M=3.96 and SD= 1. 206), professional training (M=3.96 and SD= 1. 279), seniority in the job (M= 3.82 and SD= 1. 177), and attitude towards digital technologies (M=4.75 and SD= 0.640) can affect technology acceptance remains unchanged.

The Perceived Ease of Use (PEU) of Astrocódigo (M= 21.71 and SD= 3.473) is very high. On one hand, participants indicated that serious games could provide flexibility and interaction capabilities, in particular AstroCódigo, which they found easy to use. They showed interest in serious games, both as regards learning how to use them as well as in integrating them to their classes. On the other hand, participants rated the Perceived Usefulness (PU) of using serious games as very high (M= 17.32 and SD= 2.601), after using AstroCódigo; they considered that these games could help them improve their performance. These results coincide with the ones obtained by Sanchez-Mena, Martí-Parreño, and Aldás-Manzano (2017) and Kroustalli and Xinogalos (2021).

As regards participants rated the Behavioral Intention to Use (BIU) towards serious games as high (M= 20.76 and SD= 3.247); they highlighted that using these games could be a good idea and integrating them to the teaching and learning process could be enjoyable. Similar results were presented by López et al. (2021). Likewise, participants indicate the necessity to find the adequate game and of having more training. In relation specifically to AstroCódigo and the consideration of the variable Self-Efficacy (SE), participants rated it as high (M= 11.76 and SD= 2.783), after sessions performed. They stated that they feel confident enough to use AstroCódigo and to integrate it into their educational activities. In relation to Anxiety (A), participants rated it low (M= 6.34 and SD= 3.147); only a few participants expressed some kind of concern, fear or stress about using AstroCódigo. Some expressions were found during the interviews that help to understand this last result, such as: "In my case, I would need to get closer to these technologies, for someone who is from a completely different area, and for an age issue too, my training has been outside of digital technologies, and I'm approaching it timidly, and this experience is something that allows me not to be so frightened and to feel more secure".

Finally, participants indicated that they found AstroCódigo interesting to approach the use of these technologies. It should be noted that the dimension "attitudinal competencies and technological acceptance" in Table 4 is similar in both instruments to favor subsequent comparisons and the identification of any changes in attitude as regards ICT and serious game acceptance (before and after interacting with AstroCódigo).

Table 4: Results by analysis dimension (Pre-test and post-test)

Pre-test	**Mean**	**SD**	**N**	**C***
Level of previous training in technological competencies	4.50	1.859	56	L
Internet, social media and cloud computing competencies	25.07	3.144	56	VH
Pedagogical use of digital technologies	51.89	12.579	56	H
Attitude towards digital technologies	12.30	2.304	56	H
Ethical-technological competencies	11.92	4.655	56	I
Attitudinal competencies and technological acceptance	51.23	7.644	56	VH
Serious games and technological competencies training	22.33	3.533	56	VH
Post-test				
Attitudinal competencies and technological acceptance	51.75	7.166	56	VH
Perceived Ease of Use (PEU)	21.71	3.473	56	VH
Perceived Usefulness (PU)	17.32	2.601	56	VH
Behavioral Intention to Use (BIU)	20.76	3.247	56	H
Self-Efficacy (SE)	11.76	2.783	56	H
Anxiety (A)	6.34	3.147	56	L

Note: *Classification: VL= Very Low, L= Low, I= Intermediate, H= High, VH= Very High.

Table 5: Comparison of the dimension "Attitudinal competencies and technological acceptance" in Pre-Test and Post-Test

	Pre-Test		Post-Test		N
	Mean	**SD**	**Mean**	**SD**	
I consider that a good *attitude towards digital technologies* favors their use and integration in teaching and learning processes.	4.63	0.822	4.75	0.640	56
When I perceive a digital tool as being easy to use, I feel more incentive to use it.	4.66	0.640	4.64	0.724	56
When I find a digital tool hard to use, I abandon it.	3.36	1.257	3.36	1.327	56
My academic training (*highest academic qualification*: BA, specialization, master, doctorate) has an effect on how I use and accept ICTs.	3.61	1.410	3.96	1.206	56
My basic *professional training* has an effect on how much I accept digital technologies.	3.93	1.277	3.96	1.279	56
Age affects ICT use and acceptance by academics.	3.89	1.317	3.82	1.193	56
I consider that training processes should be followed up in my work context for the acquired knowledge to be used for the development and use of technologies in the classroom.	4.70	0.737	4.64	0.699	56

RQ4. What is the academics' interest level for exploring, using, and integrating serious games into their educational activities? and RQ5. What is the academics' acceptance level about using serious games to enhance their technological skills?

The intermediate evaluation allowed the authors to carry out a comprehensive analysis of the sessions, digging deep into some factors that, according to TAM, could affect the decision to integrate this technology. In particular, serious games were considered as part of the teaching practice, and the level of difficulty, perceived benefits of the game (AstroCódigo) and overall enjoyment were examined. This evaluation addresses RQ4 and RQ5.

All participants stated that they agreed that using serious games can be beneficial to drive technological competencies and indicated that they mainly allowed them to acquire knowledge and skills related to ICTs, and computational thinking development. Participants view serious games as a new teaching and learning strategy. They valued the methodology of the sessions. These assessments coincide with the ones obtained in the study of Kroustalli and Xinogalos (2021).

In terms of difficulty, even though problem solving scenarios were increasingly difficult as the study progressed, participants showed increased confidence and expertise in using the game as the scenarios went by, which indicates a good learning curve. The first scenario requires some additional support to know how to resolve the challenge. This can be appreciated in statements such as: "…even though it may seem illogical, it was easier for me to solve the last scenarios than the first two, because I was getting acquainted with the game".

As regards comfort, participants found the game to be interesting and attractive, they seemed to be motivated (Juzeleniene et al., 2014), and they highlighted the interactive features of the game, its entertaining and dynamic nature and its ease of use as aspects they observed throughout their sessions using the game; these aspects are similar to those found by Sánchez and Emin-Martínez (2014) as well as Sanchez, Emin-Martínez and Mandran (2015).

As for enjoyment, they stated that it was linked to challenge. That is, they found that having new challenges in each scenario was an important component for enjoyment. This result could be important for the design of future serious games.

Participants stated that, during the study, they felt motivated and worked on some competencies that were required to implement methodological strategies and educational activities that incorporate ICT resources (Petcu et al., 2013), in particular, serious games. They valued the methodology that was implemented during the sessions with AstroCódigo. Similarly, they considered that the interaction with AstroCódigo allowed them to improve their analysis, reasoning, and critical thinking skills, as well as how they structure knowledge and resolve the challenges. They valued the possibility to try and fail, coinciding with what was expressed by Sanchez et al. (2014).

Overall, 96.43% of the participants indicated that they are interested in participating in training activities in relation to the acquisition of technological competencies, through the use of serious games.

Below are some results obtained in interviews with the directors of the institution. The development of technological competencies and how these competencies are being approached by the institution was analyzed. The interviews showed that there is a lack of institutional strategies to help academics develop technological competencies, as well as a lack of appropriate institutional decisions. Following some of the directors' opinions when asked: are there any strategies or projects in this branch of the Institution related to the training of faculty on the pedagogical use of TIC's? None of the 5 directors were aware of any project, which was evident in a response such as this one:

> *"As a well-structured Project, I would say no. I think there could be efforts and initiatives, but if we are referring to strategies or projects at the branch level that establish goals and indicators clearly defined, not that I am aware of."; "As far as I know, as of to date, there is no Project …"*

Similarly, the directors (5) were thoughtful in relation to identifying the factors that positively affect technological acceptance. They were specifically asked about serious games and the subsequent development of their competencies, and they mentioned factors related to institutional support, availability of technological resources and participants interest level. They also mentioned some negative factors, usually related to fear of change, age range, delayed technological access and perceived ease of use. These aspects are in line with those expressed by all the participants.

Finally, they stated that they did not know about the use of serious games as part of the academic activities carried out by academics at the institution. However, all of them said that they would support any initiatives to favor the acquisition and development of technological competencies by participants through the use of serious games. For instance, one of the directors stated: *"Yes, I would be willing to support anything related to improving technological skills. I must say that it worries me if the implementation of these Serious Games implies an additional budget from the one we manage…however, we have to continue working in improving faculty's technological competencies and we will have to use other areas to look for budget …"*

6. Conclusions

In this work, a study related to the use of serious games for the development of technological competencies in higher education academics was presented. The article contributes to knowing the barriers and possibilities in the use of serious games, according to participants´ beliefs and opinion, for their training in digital competencies, as well as their intention to use them for their integration into their own educational practices.

The results allow us to affirm that participants show a high acceptance of this type of games for the development of digital competencies. In this sense, they indicate some factors that they believe can affect the acceptance and use of the serious games, previous to the experience. After the study, some slight modifications on these beliefs were observed. However, participants considered that there might be certain factors that could negatively affect ICT use and acceptance, including highest academic qualification obtained, seniority in the job, and professional training. They also believe that the ease of use of the game and its perceived usefulness affect their intention of use. This was also supported when analyzing previous research related to TAM, where this model proved to be effective in different countries in measuring the level of acceptance of digital technologies. In this specific research, enabled the answer to different research questions (RQ2, RQ3, and RQ4) related to the level of technological acceptance and also to identify from the participants' perspective the factors that influence their attitude towards the use and acceptance of digital technologies, particularly through the use of serious games. The level of acceptance shown by the participants during the study with AstroCódigo was high, although it should be considered that from the pre-test there was a good approach, shown by participants, to the use of certain digital technologies, and they had a good attitude towards their use in the educational scenario.

Also, it is important to consider that the participants mentioned that they did not use serious games for their educational practices, so the study shows participants how to use serious games for training and development in digital competencies. They were interested in using this type of games and they were open to training in the development of digital competencies with the use of serious games. Also, AstroCódigo was found useful and easy to use, and some of them were interested in using games to work with their students, recognizing the importance of the methodology used to plan their integration. This also coincides with the investigations related

with the technological acceptance model, where the perceived ease of use and utility are related to the intention of use.

Finally, serious games were presented as an innovative, creative, and fun educational resource that allowed participants to learn, reason and develop their digital competencies. The academics of the study were motivated by the use of the game AstroCódigo, which allowed to put into practice analysis, reasoning, and critical thinking skills to resolve the challenges. The possibility to try and fail was valued by participants, which also coincides with other works mentioned in the literary review. One of the aspects mentioned about the game was the increase in the level of challenges that was related to enjoyment. This can be useful for the design of serious games.

This work opens the door to deepen in the use of serious games for the development of digital competencies for academics. As lines of future work, it is proposed to continue this research by applying the use of serious games in other scenarios for the development of digital competencies in academics. It is also proposed to address the design of serious games specifically for this purpose, considering the aspects found in this research.

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Competing interests

The authors declare no competing interests.

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