Education and Information Technologies
https://doi.org/10.1007/s10639-021-10820-9

Pre-service teachers' views about the use of digital educational games for collaborative learning

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Received: 26 July 2021 / Accepted: 15 November 2021

Abstract

Digital educational games (DEGs) constitute an effective teaching approach, particularly when they are used in combination with collaborative learning scenarios. However, when changes are made in the teaching and learning process, teachers are responsible to apply and realize them in practice. Therefore, it is vital to understand their views and attitudes on the matter, regardless if they are pre- or in-service teachers. In this work, a questionnaire was used for gathering data from 263 undergraduate students from Departments of Education in Greece, regarding their views about the use of DEGs for collaborative learning. It was found that their attitude was between neutral and slightly positive. On the other hand, their intention to use DEGs for collaborative learning was positive. It was also found that whether they consider DEGs useful and their attitude toward DEGs, were significant determinants of their intention to use them. Gender and the frequency of playing games had an impact on how useful they consider DEGs to be, while age had an impact only on pre-service teachers' attitudes toward the use of DEGs for collaborative learning.

Keywords Attitude · Collaboration · Digital educational games · Intention to use · Pre-service teachers

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Published online: 21 January 2022

1 Introduction

Games are important for the development of children's cognition, as they provide interesting and challenging learning environments, while, at the same time, improve their learning performance and their social skills (Chen & Hwang, 2014; Hwang & Wu, 2012; Vos et al., 2011). Digital game-based learning has been recognized as an effective teaching/learning approach, thanks to the game's potential to enhance students' motivation and to stimulate their curiosity and interest through activities that make sense to them (Kaimara & Deliyannis, 2019; Keller, 2010). In fact, digital educational games (DEGs) can be considered as the new paradigm for education that is based on the idea that children learn better by problem-solving in playful activities, rather than with traditional textbook-based methods (De Freitas & Liarokapis, 2011). The pedagogical approach applied to many of these games relates to their potential to function as mediators, connecting the learning objectives and the activities defined by the curriculum (Groff, 2013). Some consider DEGs as powerful learning tools and an important part of the overall educational technology. However, other researchers classify them as an educational approach, rather than just educational tools or media (e.g., Blewett, 2016).

Collaboration is not only an essential skill but also an important learning facilitator; it has a positive impact on concepts' learning, students' motivation to learn, self-esteem and confidence, and on the development of their skills (Chen et al., 2018; Kyndt et al., 2013). Therefore, the use of DEGs for collaborative learning offers additional advantages and possibilities, as theorized in the Video Game-Supported Collaborative Learning (Zea et al., 2009) and the Collaborative Game-Based Learning Approach (Romero et al., 2012).

Undoubtedly, in any educational system, learners are at the heart of it; they are the "who" of education. Then again, teachers are at the heart of the system transformation, as no change can occur without them. They are both instructors in the classroom and pivotal agents of change in education (Office of Education Research, 2018). Therefore, it is important to understand their views about DEGs (and any other educational tool for that matter), that are shaped within the wider social environment and throughout their lives (Del Pozo et al., 2017). In this respect, pre-service teachers' views about the use of DEGs for collaborative learning are as important as the ones of in-service teachers. That is because during the years individuals study to become teachers, their intentions, attitudes, and ideas about education and the tools that have an educational value are molded, forming the basis for their future educational practice. Given the above, this period is ideal for influencing their views for DEGs in order to increase the odds of using them later during their teaching (Fokides, 2017a). Equally important is to understand the factors that have an impact on their views, so as to make adjustments to their training (Fokides & Kostas, 2020).

Thus, the core questions the current study sought to answer were: (i) what are the views of pre-service teachers regarding the use of DEGs for collaborative learning, and (ii) which factors shape these views? The steps that were followed for answering these questions are detailed in the coming sections.

2 Pre- and in-service teachers' views about DEGs and their use for collaborative learning

In a society flooded with data, the educational system has to be characterized by a readiness to integrate new challenges, allowing students to discover knowledge that has meaning to them and acquire complex skills (Kaimara et al., 2021). Traditional teaching methods cannot provide convincing answers to the old question "Why should I know this?" they simply reproduce knowledge (Annetta, 2010). Approaches and teaching strategies that go beyond the model "read, write, and maths" are needed. In this respect, DEGs can play an important role as they were found to have a positive impact on learning (in terms of skills, attitudes, and knowledge) across all levels of education (e.g., Cheng et al., 2015; Masip et al., 2017; Perini et al., 2018; Topîrceanu, 2017). DEGs also cultivate learners' critical thinking, collaboration, communication, creativity, and information-seeking skills, empowering them to connect the learning content with the real world, thus, providing an answer to the above question (Fokides et al., 2019).

Collaborative learning with the use of DEGs, refers to educational activities in which students work in small groups or pairs, having DEGs as their main resource. Collaboration can occur in-game, out-of-game, or both, depending on the settings and the teaching strategy that is used. By doing so, students' learning is enhanced, given that the advantages of both DEGs and collaborative learning are exploited (Zea et al., 2009). Indeed, a systematic review of the literature concluded that the use of DEGs in the context of collaborative learning results in increased learning gains and that this approach can be used in a variety of learning domains (Del Pozo, 2015).

The majority of teachers have a positive attitude toward DEGs, as they expressed the view that they can help students to develop a wide range of strategies important for learning, such as problem-solving, deductive reasoning, and memorization (Fokides et al., 2018; Kaimara et al., 2020; Proctor & Marks, 2013). The same applies for pre-service teachers, given that the vast majority of them were positively inclined to game-based learning, considered it essential to their initial training (Cózar-Gutiérrez & Sáez-López, 2016), and considered DEGs an effective learning enhancement tool (Pastore & Falvo, 2010). Moreover, both pre- and in-service teachers were positively inclined in using DEGs during their teaching (e.g., Bensiger, 2012; Pastore & Falvo, 2010). Alas, few of them actually do so, probably due to the lack of experience (An, 2018; Gros, 2015; Van Eck,2006). Also, pre-service teachers emphasized the need for additional training, before they consider themselves able to use DEGs (Ray et al., 2014).

It seems that the literature regarding the factors that have an impact on teachers' intention to utilize (or not) DEGs is rather limited. The same applies to research regarding the use of DEGs for collaborative learning targeting pre-service teachers (e.g., Del Pozo et al., 2017). Nevertheless, Watson and Yang (2016) concluded that challenges related to the educational system, how DEGs can be effectively integrated into the curricula, and challenges related to technology use,

play an important role. A number of studies associated teachers' intentions to use DEGs with Keller's (2010) ARCS-V Motivation Model (Dempsey & Burke Johnson, 1998; Sánchez-Mena et al., 2017a). The ARCS-V model proposed five key concepts associated with a motivational design process: (i) attention, (ii) relevance, (iii) confidence, (iv) satisfaction, and (v) volition. Although Keller indicated that in order for students to become fully motivated, teachers need to discover the relevance of games to specific content areas (Kenny & McDaniel, 2011), Sánchez-Mena et al. (2017a) surprisingly, concluded that the perceived relevance did not affect teachers' attitude toward DEGs or their intention to use them. The explanation given by the authors was that teachers considered DEGs an attention driver, rather than a comprehensive teaching method. This finding is in agreement with the view that teachers are the key part of the problem regarding the integration of DEGs into the classroom. It is also related to the perception of technology as a tool rather than as a system or set of affordances (Blewett, 2016).

DEGs, as part of technology-enhanced learning, can also be studied in the broader context of technology acceptance in education (Hwang & Wu, 2012). Even though there are quite a lot of different models that try to explain how, why, and under which conditions various groups (the educators included) accept or reject the use of technology, most are based on the Theory of Reasoned Action (TRA) proposed by Ajzen and Fishbein (1980). In short, this theory is an effort to explain (and predict) human actions by proposing a set of relationships between attitudes and behavioral intentions. On the basis of TRA, Davis et al. (1989) proposed the Technology Acceptance Model (TAM). TAM models the causal relationships between the perceived ease of use of a given technological tool, its perceived usefulness, the users' attitude toward the tool, and their behavioral intention to use it (Fig. 1).

TAM, besides being acknowledged as a parsimonious and robust model, it has been widely used for examining teachers' acceptance of various technological tools. For example, perceived usefulness, perceived ease of use, computer self-efficacy, and attitude toward computer use were found to be significant determinants of pre-service teachers' intention to use computers (Fokides, 2017a; Teo et al., 2012). Similarly, pre-service teachers concluded that perceived usefulness and perceived ease of use were the most influential factors to their intention to use 3D multi-user virtual environments when they become in-service teachers (Fokides, 2017b). In the case of DEGs, perceived usefulness directly and positively influenced teachers' behavioral intention to use them; perceived ease of use did not have a direct effect but indirectly influenced intention through perceived usefulness, while participants' attitude

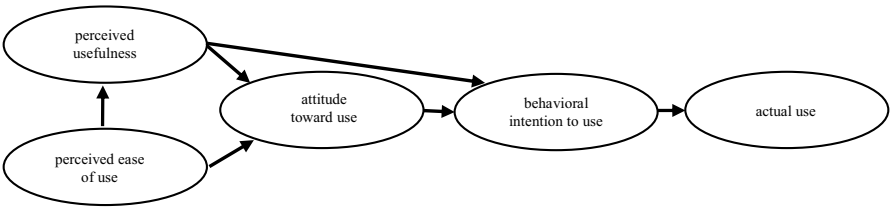

Fig. 1 The Technology Acceptance Model

toward DEGs also had a significant impact on their behavioral intention to use them (Sánchez-Mena et al., 2019).

In addition to teachers' views, other factors also encourage or discourage them from using DEGs, related either to their background or to games per se as they have features that are considered challenging. For instance, Bourgonjon et al. (2013) as well as Kenny and McDaniel (2011), found that only a small minority played video games regularly. Lack of experience may explain why most of them considered video games as being too complicated (Kenny & McDaniel, 2011). The game design and gaming experience had a positive influence on teachers' attitudes, self-efficacy, and perceptions regarding the use of DEGs in the classroom (An & Cao, 2017). Del Pozo et al. (2017) found that even though pre-service teachers were positively inclined toward the use of DEGs for collaborative learning, the attitude of males and students who play video games frequently, was more positive. Interestingly enough, another study that had pre-service teachers as a target group, concluded that there was no statistically significant difference between non-video game players and frequent video game players in their intention to use DEGs and both groups had a statistically significantly lower mean score, compared to other groups (Jenny et al., 2013). In addition, female pre-service teachers, compared to males, believed that it is hard to use DEGs in the learning process (Bensiger, 2012).

3 Research model and hypotheses formation

As mentioned in the preceding section, few studies examined the attitude of pre- and in-service teachers toward the use of DEGs for collaborative learning and even fewer utilized TAM or other similar models. Moreover, there are studies with contradictory results. Given the scarcity of research in this field, the study at hand is an initial attempt to fill this gap, as it sought to examine the following hypotheses:

- H1. *Pre-service teachers consider useful the use of DEGs for collaborative learning.*
- H2. *Pre-service teachers'* attitude toward the use of *DEGs for collaborative learning* is positive.
- *H3. Pre-service teachers intend to use DEGs for collaborative learning.*

Furthermore, inspired by TAM, a model was formulated, as presented in Fig. 2, which tried to encapsulate the relationships of factors that might affect pre-service teachers' intentions to use DEGs for collaborative learning. On the basis of this model, the following hypotheses were set:

- *H4. How useful pre-service teachers consider the use of DEGs for collaborative learning, has a positive impact on their attitude toward them.*
- *H5. How useful pre-service teachers consider the use of DEGs for collaborative learning, has a positive impact on their intention to use them.*
- *H6. Pre-service teachers' attitude toward the use DEGs for collaborative learning, has a positive impact on their intention to use them.*

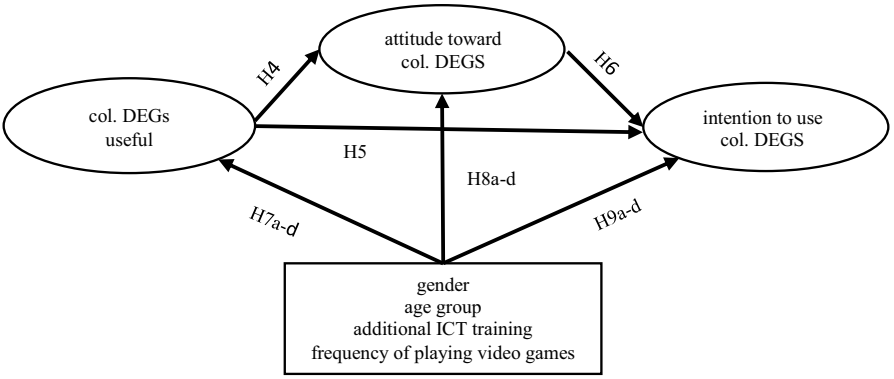

Fig. 2 The proposed model

- *H7a-d.* Gender (a), age (b), additional ICT training (c), and frequency of playing video games (d), significantly influence how useful *pre-service teachers consider the use of DEGs for collaborative learning.*
- *H8a-d.* Gender (a), age (b), additional ICT training (c), and frequency of playing video games (d), significantly influence *pre-service teachers' attitude toward the use of DEGs for collaborative learning.*
- *H9a-d.* Gender (a), age (b), additional ICT training (c), and frequency of playing video games (d), significantly influence *pre-service teachers' intention to use DEGs for collaborative learning.*

In this study, the dependent variable was pre-service teachers' intention to use DEGs for collaborative learning, while all the other factors acted as independent variables. Because structural equation modeling (SEM) was going to be used for model testing, participants' gender, age group, their additional ICT training, and the frequency they play video games, were used as control variables.

4 Method

4.1 Participants and procedure

Undergraduate students studying at Greece's Departments of Primary Education were the study's target group. The only prerequisite for participating was students to have attended at least one course related to DEGs. For that matter, there was a relevant question in the online questionnaire that was used (as presented in section "Instrument"). Having some basic knowledge about DEGs was considered important, because, otherwise, the validity of participants' views would have been questionable. Responses coming from participants stating that they did not study any

courses related to DEGs, were excluded from the subsequent data analysis. As a result, the study's sample size was 263 individuals. An invitation was posted to relevant students' groups on Facebook and other social media addressed to anyone interested to participate in the study. The participants were informed that the study was conducted voluntarily, it was anonymous, no personal data were collected or stored, and that consent to participate will be deemed to have been given by completing the questionnaire.

4.2 Instrument

As already mentioned, a self-report online questionnaire was used, consisting of two sections. The first section was about demographic data, namely gender, age group, whether participants have received ICT training other than the one included in their courses, how frequently they play video games, and whether they have attended courses related to DEGs. The second section was about participants' attitude toward DEGs for collaborative learning, whether they deem them useful for their students, and whether they intend to use them in their teaching. The questions in this section were drawn from the Greek version of Del-Pozo et al.'s (2019) scale, developed for measuring in-service teachers' attitude toward collaborative learning using video games (Authors 2020). Even though it includes six factors, three were selected (having a total of seventeen items), that were considered the most well-suited for the study. The items were presented in a five-point Likert-type scale, anchored at strongly disagree (1) and strongly agree (5).

5 Results

5.1 Initial data processing and descriptive statistics

The questionnaires' responses were imputed into SPSS 26. No missing data were found. Also, there were no unengaged responses (i.e., ones in which the standard deviation was less than 0.50). Out of the 263 participants, 70.3% ($n=185$) were females. As expected, most belonged to the 18–23 years old group (68.4%, $n=180$) and the 24–30 years old group (19.4%, $n=51$). 62.0% of the participants ($n=163$), did not receive any additional ICT training other than the relevant university courses. As for their gaming experience and quite interestingly, 25.3% ($n=43$) have never played video games, 37.6% ($n=64$) rarely play (up to three times a month); 23.0% ($n=39$) and 14.1% ($n=24$) play frequently (up to three times a week and every day respectively).

Because only certain items were selected from the Greek version del Pozo et al.'s scale (Authors 2020), it was deemed necessary to assess the validity and reliability of the second part of the questionnaire. For that matter, an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) were conducted. The EFA established the questionnaire's underlying factorial structure. Five items had to be dropped because their communalities were below the .50 threshold and/or they had

Table 1 The questionnaire's convergent and discriminant validity

	CR	*AVE*	Usefulness	Attitude	Intention
Usefulness of DEGs for collaborative learning	0.855	0.596	**0.772**		
Attitude toward the use of DEGs for collaborative learning	0.846	0.524	0.697	**0.724**	
Intention to use DEGs for collaborative learning	0.873	0.633	0.771	0.693	**0.796**

AVE Average Variance Extracted; CR: Critical ratio; diagonal: square root of AVE extracted from observed variables; off-diagonal: correlations between constructs

Table 2 Descriptive statistics for the questionnaire's factors

Factor	*M*	*SD*	95% confidence interval	
			Lower bound	Upper bound
Usefulness of DEGs for collaborative learning	3.96	0.67	3.88	4.05
Attitude toward the use of DEGs for collaborative learning	3.41	1.52	3.23	3.60
Intention to use DEGs for collaborative learning	4.21	0.79	4.11	4.31

significant loadings in more than one factor (Hair et al., 2010). After removing the problematic items, the EFA was reconducted. Three factors, each having four items, emerged from the analysis that were labeled as "Usefulness of DEGs for collaborative learning," "Attitude toward the use of DEGs for collaborative learning," and "Intention to use DEGs for collaborative learning." The constructs' consistency, as assessed using Cronbach's α, was good since, in all cases, the values exceeded the .70 threshold (ranging between .79 and .85 for the constructs, while the overall score was .82) (DeVellis, 2016). For conducting the CFA the factorial structure was imputed into AMOS 25. For checking the questionnaire's convergent validity, the average variance extracted (AVE) was used; for assessing its discriminant validity, the square root of AVE for any given factor was compared with the correlations between this factor and any other factor. As presented in Table 1, there were no issues with both the convergent and discriminant validity, given that all critical ratios were above the.70 threshold and the variance a factor shared with the other factors was less than the variance it shared with its items (Hu & Bentler, 1999). Thus, it can be concluded that there were no issues with the questionnaire's validity and reliability. Its items are presented in the Appendix.

5.2 Results on the views of pre-service teachers for the use of DEGs for collaborative learning

As the questionnaire's data were reliable, three new variables were calculated, representing the items' average in each factor. From Table 2 it can be inferred that participants' attitude toward the use of DEGs for collaborative learning was between neutral/indifferent and slightly positive, as the mean for this factor was slightly above the midpoint and the standard deviation was quite wide ($M = 3.41$, $SD = 1.52$). Thus,

H2 can neither be confirmed nor rejected. As for H1, it can be accepted with some reservations; the participants considered useful the use of DEGs for collaborative learning, but they were not overwhelmingly positive ($M = 3.96$, $SD = 0.67$). On the other hand, H3 can be confirmed; pre-service teachers are willing to use DEGs for collaborative learning, given that the mean for this factor was above the 4.0 mark ($M = 4.21$, $SD = 0.79$).

5.3 Structural equation modeling

As SEM was to be performed for model testing using AMOS 25, several tests were conducted for checking whether the data were fit for this type of analysis. The sample size was acceptable given that it was above 150 cases ($N = 263$) (Hair et al., 2010). A curve estimation of all the relationships in the model revealed that they were sufficiently linear. There were no outliers or influential cases. Abnormal Cook's distance was not an issue (in all cases it was < .25). The highest value of the Variance Inflation Factor that was observed was 1.97, well below the recommended maximum of 3. Also, in all cases, Tolerance was well above the recommended minimum value of .1 (O'Brien, 2007). Therefore, there were no issues with multicollinearity. For ruling out the Common Method Variance (CMV), a common latent factor was added and the standardized regression weights before and after adding this factor were compared (Gaskin, 2013). As the difference was below .1, it was concluded that the CMV was not an issue.

The analysis of the direct effects in the initial model revealed that there were several not statistically significant ones and some path coefficients were small. Given that, the overall model could be improved by removing these problematic paths. For that matter, the Specification Search Facility was used, all the direct effects were made optional, a hierarchy of $2^{15} = 32{,}768$ models was examined, and the model with the smallest value for BCC_0 ($BCC_0 = 0.00$) was selected as the final model (Burnham & Anderson, 1998). In this model, several paths were removed together with the factor labeled as "Additional ICT training," as it had no effect to any other factor. All the fit indices of the final model, as presented in Table 3, were excellent except for χ^2, which usually indicates significant

Table 3 Fit indices for the final model

Measure	Estimate	Threshold	Interpretation
CMIN	190.539	–	–
DF	116.000	–	–
χ^2	< .001	> .05	unacceptable
CMIN/DF	1.643	Between 1 and 3	excellent
CFI	.96	> .95	excellent
SRMR	.03	< .08	excellent
RMSEA	.05	< .06	excellent
PClose	.51	> .05	excellent

Note. Cutoff criteria by Hu and Bentler (1999)

differences when the sample size exceeds 200 cases (Hair et al., 2010); thus, it was considered an acceptable deviation from was is recommended.

A model's explanatory power is determined by its high squared multiple correlations ($R^2 > .50$) and by its significant structural paths (β close to .20 and ideally above .30) (Chin, 1988). It can be concluded that the final model's explanatory power was rather good, given that (i) the R^2s were high except for one factor ($R^2 = .15$ for the factor "Usefulness of DEGs for collaborative learning," $R^2 = .56$ for the factor "Attitude toward the use of DEGs for collaborative learning," and $R^2 = .66$ for the factor "Intention to use DEGs for collaborative learning ") and (ii) the structural paths were substantial. It was also checked whether the factor "Attitude toward the use of DEGs for collaborative learning" acted as a mediator of the effects the factor "Usefulness of DEGs for collaborative learning" had on the factor "Intention to use collaborative DEGs." Indeed, it was found that there was a statistically significant partial mediation effect ($\beta = .52$, $p = .001$). The post-hoc power analysis was performed using the method described by Soper (2016). For the six predictors of the factor "Intention to use DEGs for collaborative learning," 263 cases, an observed R^2 of .66, and a probability level of .05, the statistical power was 1.00. Thus, it can be concluded that the model had an excellent power to detect the significant effects, while the non-significant effects were indeed not significant. Table 4 and Fig. 3 present the final model and the hypotheses that were accepted.

Table 4 Hypotheses testing results

Hypothesis	Path	Path coefficient (β)	*t*-value	*p*	Outcome
H4	usefulness ➔ attitude	.73	9.15	< .001	accepted
H5	usefulness ➔ intention	.30	3.52	< .001	accepted
H6	attitude ➔ intention	.56	6.39	< .001	accepted
H7a	gender ➔ usefulness	.23	3.67	< .001	accepted
H7b	age ➔ usefulness	−.05	−0.81	.420	rejected
H7c	ICT training ➔ usefulness	.10	1.63	.103	rejected
H7d	frequency of playing video games ➔ usefulness	.31	4.71	< .001	accepted
H8a	gender ➔ attitude	.05	1.01	.310	rejected
H8b	age ➔ attitude	.16	3.19	.001	accepted
H8c	ICT training ➔ attitude	−.07	−1.45	.146	rejected
H8d	frequency of playing video games ➔ attitude	.05	1.95	.051	rejected
H9a	gender ➔ intention	.07	1.59	.113	rejected
H9b	age ➔ intention	−.03	−0.69	.492	rejected
H9c	ICT training ➔ intention	.05	1.18	.237	rejected
H9d	frequency of playing video games ➔ intention	.03	0.73	.468	rejected

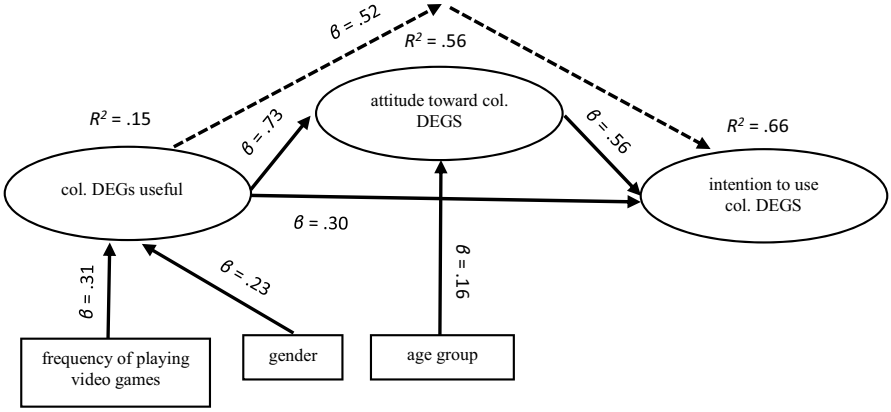

Fig. 3 The final model. *Note*. The dotted arrows represent the mediation effect

6 Discussion

The study attempted to give answers to questions regarding the views and feelings of pre-service teachers regarding the use of DEGs for collaborative learning. It was found that they were quite positively inclined toward using them ($M = 4.21$, $SD = 0.79$), confirming past research (e.g., Bensiger, 2012; Fokides et al., 2018; Kaimara et al., 2020; Pastore & Falvo, 2010). It was also found that pre-service teachers considered the use of DEGs in collaborative settings, as being a teaching approach that can benefit students, though their responses were not so positive as they were in their intention to use them ($M = 3.96$, $SD = 0.67$). Again, this finding is in line with past research which indicated that both pre- and in-service teachers recognize the positive impact DEGs have on students' knowledge and skills (e.g., Cheng et al., 2015; Cózar-Gutiérrez & Sáez-López, 2016; Kaimara & Deliyannis, 2019; Keller, 2010; Masip et al., 2017; Pastore & Falvo, 2010; Perini et al., 2018; Topîrceanu, 2017). On the other hand, the data analysis revealed that pre-service teachers' attitude toward DEGs was, somehow, neutral ($M = 3.41$, $SD = 1.52$), very close to what del Pozo et al. (2017) found in their study.

One might think that the above results are inconsistent or even contradictory; pre-service teachers understand that DEGs are useful, intend to use them but, at the same time, they are a bit cautious or reserved. What has to be stressed is that the behavioral intention to use a technological tool in an educational context and the understanding of its usefulness, do not automatically translate into an actual use of this tool. Although TAM makes this assumption, educators around the world do not use technology extensively in their teaching, despite their good intentions (Organisation for Economic Co-operation and Development, 2015). DEGs are not an exception to the above rule; lack of experience was cited as an important inhibitory factor (An, 2018; Gros, 2015; Van Eck, 2006), together with challenges related to technology use and the educational system (Watson & Yang, 2016). In addition, in previous studies, pre-service teachers highlighted the need for additional training, before they consider themselves as being able to use DEGs (Ray et al., 2014). It can be

supported that the study's results regarding their attitude toward the use of DEGs for collaborative learning reflect these concerns.

Having TAM as a basis, the study also tried to explore the relationships of factors that were theorized to have an effect on pre-service teachers' intention to use DEGs for collaborative learning. It was found that the R^2 for the dependent variable was .66, meaning that 66% of the variance in this factor was explained by just two factors, namely attitude toward and perceived usefulness of DEGs for collaborative learning, both having substantial direct structural paths linking them to the dependent variable ($\beta = .56$ and $\beta = .30$ respectively). It was also found that the perceived usefulness of DEGs had an impressive direct effect on attitude ($\beta = .73$), allowing for the explanation of 56% of the variance in this factor ($R^2 = .56$) and a significant indirect effect on behavioral intention through attitude ($\beta = .52$). Therefore, it can be concluded that the model more than adequately represents the factors' relationships and possesses the power to explain pre-service teachers' behavioral intention to use DEGs in the context of collaborative learning. Even though it was beyond the study's scope, the high R^2s and the strong structural paths, give further support to the notion that TAM is a simple, yet, a rather efficient model, for explaining the behavioral intention of using technology, applicable to various groups of professionals. In general, it is supported that beliefs (e.g., perceived usefulness) together with attitude shape the intention of educators (either pre- or in-service) to use technology during their teaching (e.g., Fokides, 2017a, 2017b; Macharia & Pelser, 2014; Teo et al., 2012). Moreover, the model that emerged from this study has many similarities with the one suggested by Sánchez-Mena et al. (2019) who also employed TAM; although their study involved in-service teachers the same two factors were found to shape participants' intention to use DEGs and, in most cases, the structural paths were equally strong.

Out of the two factors, it seems that the attitude toward DEGs was the most significant determinant of the behavioral intention to use them and it was substantially influenced by DEGs' perceived usefulness. This finding is consistent with the research highlighting the close and strong relationship between the attitude toward the use of a technological tool and the intention to use it (e.g., Teo, 2010). This also applies to pre-service teachers; their positive attitude toward a tool determined how willing they were to use it (e.g., in the context of computers, Fokides, 2017a; in the context of virtual environments, Fokides, 2017b). The relationship between the perceived usefulness of a technological tool and the likelihood of using it was found even in the earlier studies related to computer acceptance (Davis et al., 1989), but also in studies that identified this factor as a predictor of secondary school teachers' behavioral intention to use DEGs (Bourgonjon et al., 2013). The strong impact the perceived usefulness of a technological tool has on teachers' attitude toward it was also suggested by past research (in the context of in-service teachers, Teo, 2011; in the context of pre-service teachers, Teo, 2009).

As for the control variables, some interesting results emerged. Participants' age affected only their attitude toward DEGs (but it was the weakest structural path, $\beta = .16$). This is probably a circumstantial finding, given that the age disperse was narrow and uneven (around 70% of the participants were between eighteen and twenty-three years old and around 90% of the sample was below the age of thirty).

Thus, the age distribution was not sufficient enough to allow the effects of this factor -if they exist- to manifest themselves. On the other hand, this problem was expected, as a target group was having university students.

Quite interestingly, gender had a (positive) effect only on the perceived usefulness of DEGs for collaborative learning ($\beta = .23$). The existing literature suggested that age and gender are predictors of attitude toward DEGs (Del Pozo et al., 2017; Sánchez-Mena et al., 2017b). It was also found that male pre-service teachers are more positively inclined toward the use of DEGs for collaborative learning (Del Pozo et al., 2017) and that female pre-service teachers find it hard to use DEGs in the learning process (Bensiger, 2012). None of the above were confirmed by the findings of this study. On the contrary, it was found that female pre-service teachers consider DEGs more useful for collaborative learning compared to their male counterparts. Differences among the studies' samples can offer a probable explanation for this discrepancy in the results. Another probable explanation is that, as younger generations of "digital natives" begin to study to become teachers, their long-standing immersion in technology allows for gender differences to ease.

Finally, it was found that the frequency of playing video games had a -rather significant- impact only on perceived usefulness ($\beta = .31$). Past research did not offer consistent results for the impact of this factor. Some suggested that pre-service teachers who frequently play video games were more positively inclined toward the use of DEGs for collaborative learning compared to non-gamers (Del Pozo et al., 2017). Others suggested that there were no statistically significant differences between non-video game players and frequent video game players in their intention to use DEGs (Jenny et al., 2013). This study suggests that the only existing path is between the frequency of playing video games and the perceived usefulness of DEGs, with the ones who frequently play having stronger positive beliefs for DEGs' usefulness. The lack of paths linking frequency with attitude and/or behavioral intention is more important than the path linking frequency with usefulness, as this challenges the literature in which video games were analyzed as a leisure activity (Sánchez-Mena et al., 2019). A probable interpretation is that, while gamers, drawing from their experiences in playing video games, are likely to have a more comprehensive idea for the usefulness of DEGs, being a gamer is not the pivotal factor for deciding whether to use games in an educational context, as leisure and education differ quite a lot.

6.1 Implications for practice

The literature suggested that teachers, despite their good intentions, do not often use DEGs in their teaching (An, 2018; Gros, 2015; Van Eck, 2006). What is more, pre-service teachers felt that they need training so as to become able to use DEGs (Ray et al., 2014). In this respect, it is the responsibility of policymakers, university administrators, and academics to plan and implement interventions in order to create the critical mass of educators needed for turning DEGs and collaborative learning into a mainstream educational tool and teaching strategy. As a result, several changes to pre- and in-service teacher training curricula and professional

development programs should be made in order to influence the educators' beliefs for DEGs. This is because pre- and in-service teachers' beliefs are the driving force of the way they teach (or will tech) (Sugar et al., 2004). Thus, it is rather important to understand how these beliefs are shaped. Toward this end, the study established that the attitude toward DEGs, together with their perceived usefulness are powerful predictors of pre-service teachers' intention to use them. Given that, one has to come up with ways to positively influence these factors.

Wong et al. (2006) suggested that discrete ICT training positively affects pre-service teachers' attitudes toward technology. On the basis of the above, academics can design courses that focus on providing pre-service teachers the opportunity to design their gaming environments, to explore ways to incorporate collaborative gaming activities into the classroom or in informal learning environments, and, thus, to become more actively involved in game selection and integration, which, in turn, will allow them to understand DEGs' potential (An, 2018; Kenny & Gunter, 2011). It is also known that organizational factors (e.g., collaborative culture, strong leadership, motivated staff, and positive ethos) strongly influence attitudes (Grainger & Tolhurst, 2005). Margaryan et al. (2011) suggested that university students' attitudes are influenced by their lecturers. Given that, higher education teachers need to become role models, demonstrating innovative and well-organized uses of DEGs in the context of collaborative learning.

It is suggested that teachers' perceived usefulness of any ICT tool is positively influenced when the use of this tool is linked with feasible teaching practices that help them to become more efficient and effective in their teaching (Ottenbreit-Leftwich et al., 2010). Therefore, the perceived usefulness of DEGs can be influenced if teachers are provided with experiences on how they can be applied to specific content areas and by providing evidence for the positive outcomes that can be achieved.

Finally, one has to be reminded that technological developments are constant. Also, users' positive perceptions of the educational uses of a technological tool might change over time and they might develop avoidance behaviors. In addition, Gu et al. (2013) suggested that students expect to be engaged with technology at their place of learning. Taken together the above, it is advised university teachers to remain responsive to changes regarding DEGs, so as their students to keep pace with the technological developments. By doing so, their behavioral intention to use DEGs might also become stronger.

6.2 Limitations and future work

There are limitations to this work that have to be acknowledged, the first one being the use of an online questionnaire for data collection. It is probable that only students favoring this method participated in the study, affecting the results' generalizability. In this respect, online together with paper-and-pencil questionnaires could have been used. Secondly, there is no way of knowing participants' honesty and accuracy of their responses. Then again, this limitation applies to all studies in which questionnaires are used. Even though data were collected from all the Departments of Education in Greece, the curricula and practices vary;

there are differences in the courses examining the use of DEGs. Because of that, there can be differences in students' views coming from different departments. Fluctuations in the results can also be expected because of the participants' varied previous experience with DEGs. The study was limited to Greek students. Thus, the results reflect the situation only in this country. Finally, though the intention to use DEGs for collaborative learning was explained quite adequately ($R^2 = .66$) by the study's variables, still, 34% was left unexplained, meaning that other variables come into play but their impact was not accounted for.

The above limitations can function as guidelines for future work. Larger sample sizes, the inclusion of students from other countries, and the inclusion of individuals studying to become educators in different levels of education can certainly provide a clearer picture regarding their beliefs and views for this tool. The addition of more factors can probably explain more thoroughly the intention of using DEGs. Studies comparing the views of pre-service teaches having varied previous experience with DEGs and collaborative learning, will help to better understand how different groups intend to utilize both during their teaching. Also, more studies are needed for establishing (or rejecting) the model's overall validity and applicability. Finally, longitudinal studies can help to understand how views are shaped and change over time, specifically, when pre-service teachers become in-service teachers and other factors start having an impact on their views.

7 Conclusion

The use of technology in the educational milieu is important; therefore, there is the need for an in-depth examination of the factors that facilitate teachers' acceptance of various ICT tools, including DEGs. Then again, only a handful of studies examined pre-service teachers' views about DEGs and even less in the context of collaborative learning. In this respect, the study contributes to the existing literature by providing evidence that although pre-service teachers' attitude toward the use of DEGs for collaborative learning is, somehow, neutral, they also considered them as useful educational tools, and they intend to use them for collaborative teaching. Moreover, a model was proposed and tested, which adequately mapped the relationships of factors influencing the above intention. It was determined that the perceived usefulness of the tool strongly influences both the attitude toward it and the intention to use it. In addition, it was found that attitude is a significant determinant of pre-service teachers' intention of using DEGs for collaborative learning. Quite interestingly, the participants' age had a (weak) effect only on their attitude toward DEGs, while their gender and the frequency they play video games had a considerable impact only on how useful they think that DEGs are. Setting aside the limitations of the study, the above observations might prove useful to education policymakers but also to university educators for curriculum planning and for devising suitable strategies aiming to shape university students' beliefs for DEGs.

Appendix

The items in the questionnaire's second section

Factor: Attitude toward collaborative DEGs

1. The use of digital games for collaborative learning activities is a waste of precious time.*
2. Teacher training on the use of digital games for collaborative learning is a waste of time.*
3. The use of digital games for collaborative learning is a distraction from, and an impediment to, completing the course syllabus.*
4. The use of digital games for collaborative activities is an inappropriate or ineffective teaching method.*

Factor: Usefulness of collaborative DEGs for students

5. The use of digital games for collaborative learning activities increases students' self-esteem.
6. The use of digital games for collaborative learning discourages students from taking learning seriously.*
7. The use of digital games for collaborative activities increases students' curiosity to learn more.
8. The use of digital games for collaborative activities increases students' motivation and ability to "take the initiative."

Factor: Intention to use collaborative DEGs

9. I would like to work in a school that supports the use of digital games for collaborative learning activities with students.
10. I would never use digital games for facilitating collaborative learning activities.*
11. If there were sufficient resources within my school, I would definitely use digital games to facilitate collaborative learning activities in the classroom.
12. I would refuse to use digital games for collaborative learning activities in the classroom, even if my students ask me to do so.*

Author's contributions All authors contributed to the manuscript equally.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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