Pre-Service Teachers' Attitudes Toward Integrating Digital Games in Learning as a Means for Developing High-order Thinking and Lifelong Learning-insights for Training

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This study explores the influence of pre-service teachers’ training characteristics on the integration of digital games into their teaching. Specifically, pre-service teachers’ perception of their individual techno-pedagogical knowledge, their attitudes regarding games as an effective tool for developing higher-order thinking and fostering lifelong learning. The research methodology of the study is quantitative and supported by qualitative findings. The research sample consisted of 108 pre-service teachers who responded to a questionnaire that followed a 2X2 research model; between those that could have learned or not learned about digital games, and those who could have taught or not taught the subject with digital games. The findings indicate that there is a positive correlation between pre-service teachers who worked with digital games during their training and their attitudes towards the integration of digital games in learning. In addition, those with direct experience of digital games believed that they have a higher level of techno-pedagogical knowledge and felt more confident ng teaching their colleagues how to integrate digital games into instruction. In a similar vein, the pre-service teachers who had direct experience teaching with digital games reported that their students’ thinking processes and lifelong learning skills increased as a result of playing such digital games. The findings from this study have both theoretical and practical applications in the training of pre-service teachers in the area of integrating digital games for higher-order thinking and lifelong learning.

Keywords: digital game-based learning; pre-service teachers' perceptions; teachers' education; high-order thinking; lifelong learning.

**Literature review**

***Digital games in education***

The term “edutainment” describes a variety of media-based tools that provide information and learning opportunities alongside enjoyment and entertainment (Rapeepisarn, Wong, Fung & Depickere, 2006; Egenfeldt-Nielsen, 2011). One such tool is the educational game,digital games that are integrated into educational plans (Gee, 2003; Prensky, 2008). The benefits of educational digital games is well-known to educators and researchers (Connoly et al. Whitton, 2014; 2012), and they have consequently been successfully incorporated as learning and training tools across a broad range of areas (Breuer & Bente, 2010; Ritterfeld, Cody, & Vorderer, 2009). They are especially effective in contributing to the development of the cognitive schema, the patterns of thought that contain the knowledge and opinions of a person towards a given subject (Piaget,1962).

“Game-Based Learning” is a teaching approach that integrates gamified elements into the learning process. It contains elements of competition, involvement, and immediate reward. Through the playing/learning process, player-learners receive immediate feedback, allowing them to compete with either a computer or other player-learners, to achieve educational goals. A game-based environment invokes a sense of challenge and is characterized by high levels of intrinsic motivation (Hawlitschek & Joeckel, 2017), as well as a narrative framework, which helps the player-learner in the educational activity while at the same time facilitating skill-building and knowledge growth (Squire, 2011; Connoly et al., 2012; Gee, 2003). “Digital Game-Based Learning” (or DGBL) is an approach born of the continued use of computer games and applications of educational worth (Prensky, 2003; Ethel & Jamet, 2013). Studies report strong educational potential for the use of digital game-based learning, citing the enjoyment and interest they inspire (Dickey, 2011; Burguillo, 2010), and the ease of integration into the development process of children and teenagers (Yien, Hung, Hwang & Lin, 2011; Kim, Park & Baek, 2009). For example, in a comparative study conducted with children in South American countries, a considerable difference was found concerning mathematical knowledge acquired between students using digital games and those using traditional methods, with digital games proving more beneficial. It was also found that the interest levels of the students using games were higher than their traditionally-trained counterparts, excluding low-performing students (Beserra & Nussbaum, 2014).

Although the world of games is supposedly separate from reality, it allows learners to acquire lifelong learning skills and 21st-century skills. Through digital learning games, one can develop digital literacy and learning skills, learn practices of life skills and personal skills relevant to the job market, develop social and interpersonal skills, and even develop personal skills such as creativity, self-discovery, and critical thinking. Indeed, in the context of lifelong learning skills the digital game has considerable scope(Alt & Raichel, 2019). However, to realize this potential it is important to distinguish between two types of digital education games: those that were developed specifically for educational purposes and those that were initially designed for entertainment then adapted for educational purposes. In this article, we will be focusing on the former. A distinction must be made between games created by professionals and those created by teachers or students (Stewart et al., 2013). This research is concerned with games created specifically for educational purposes and implemented by teachers.

Integrating games into learning systems to encourage thinking development can be categorized into two approaches (Pivec, Dziabenko & Schinnerl, 2003; Kafai, 2006): (1) “Instructionist” approach - Students play a game developed by a teacher/professional to practice and assimilate information concerning a certain subject. Some teachers prefer to use the game solely as an introduction to the class, others use it as the main element of the class, while others use it as a conclusion to the class or assign it as homework. Games can be integrated into an individual or group setting, inside the classroom or outside (Eyal, 2016). (2) “Constructionist” approach - Students design games themselves in a creative and personal manner, as part of the learning process. In this approach, the students explore and understand the learning material through designing and playing the game (Pivec, Dziabenko & Schinnerl, 2003), thereby developing and enhancing their thinking skills.

This observation is important due to the level of thinking it encourages in students. Bloom’s taxonomy of cognitive skills (Bloom,1956) provides a helpful model in this context. The original model proposed six categories of cognitive skills ranging from lower-order skills that require less cognitive processing to higher-order skills that require deeper learning and a greater degree of cognitive processing. Based on the findings of cognitive science, a later revision of the taxonomy changed the order of the cognitive processes and repositioned synthesis rather than evaluation at the highest level of the hierarchy (Anderson & Krathwohl, 2001). In this revised version, the levels are remembering, understanding, applying, analyzing, evaluating, and creating. Moreover, this revision adds a new dimension across all six cognitive processes. It defines four types of knowledge that might be addressed by a learning activity: factual (terminology and discrete facts); conceptual (categories, theories, principles, and models); procedural (knowledge of a technique, process, or methodology); and metacognitive (including self-assessment ability and knowledge of various learning skills and techniques). Bloom's taxonomy has been used to create and align objectives, lessons, and assessments to achieve all cognitive levels of the traditional classroom (Anderson & Krathworthl, 2001; Chyung, 2003) and have been validated in E-learning (Skyler et.al, 2005) and virtual learning environments (Piccoli et.al., 2001, Vidakovic et.al., 2003). We will argue that a “constructionist” approach includes higher levels of thinking, unlike an “instructional” approach which fosters lower levels of thinking.

In the digital era, online game generators enable the quick and simple creation of games with a high level of functionality and design. These existing digital platforms require no prior knowledge of coding, rather serving as editing tools for generic templates into which different types of content can be entered. These generators enable the swift creation of simple yet accessible and streamlined games, that include low-order strategic practice and, more importantly, data recall and basic understanding. The transfer of the creative process unto the learners allows them to use high-order strategic thinking in the form of strategic planning, decision making, comparison, data presentation in multiple forms, problem-solving and collaborative learning (Eyal, 2016; Yang & Chang, 2013; Deater-Deckard et al., 2013; Mischer-Tal & Lyba, 2018).

***Teacher education and digital games***

Teaching with games requires adaptive expertise which may not be intuitive to all teachers (Eastwood & Sadler, 2013). According to the TPACK model (Mishra & Kohler, 2006) for the creation and development of these educational games to be properly suited to the learning plan and educational requirements, the teacher must guide the students through this complex technologically-inclined educational process. Teachers should have a positive attitude towards the subject, as well as technical-pedagogical capabilities, with sufficient knowledge of the subject (Avidov-Unger & Arzi-Cohen, 2014; Hsu, Liang, Su, 2015; Molin, 2017). Foster & Shah (2020) examined the principles that emerge from teacher education in game-based learning and identified six principles that can guide research and practice in teacher education for GBL: (a) teachers play an active role in GBL environments; (b) games are a form of the curriculum; (c) GBL is a way of facilitating learning; (d) games are not contextually or pedagogically neutral; (e) teachers’ knowledge of GBL evolves over time; and (f) teachers’ professional identities impact GBL practice.

In light of these findings, we argue that it is imperative for pre-service teachers topartake in the appropriate training processes. Teaching with games, we posit, would include the examinations of practices involved before, during, and after game-based interventions (Kangas et al., 2016; Foster & Shah, 2020). We suggest that an effective training design might be underpinned by Kolb's Experiential Learning model (Kolb, 1984, Liege & Janicki, 2006), rather than the traditional learning methods. In Kolb's model, knowledge is created from grasping and transforming one's experiences. His model describes four phases in the learning cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. An important characteristic of this theory is that its different phases relate to particular learning styles. The theory states that while almost every learner utilizes all four phases to some extent, individuals have a preferred learning style. Kolb's model has been asserted as a learning theory that confirms all main aspects of active learning (Anderson & Adams, 1992) and advances theoretical argument of independent learning, learning by doing, work-based learning, and problem-based learning (Akkoynulu & Soylu, 2008).

When embarking on student games development, teachers will need many skills, namely familiarity with a plethora of game-generating platforms; the ability to instruct and guide group educational processes; and, guiding students to make decisions regarding the correct generator suited to their needs. Teachers should be able to educate and cultivate self-learning. We have noted a wide gap between prevailing policies promoting educational technology-related reform and realities that teachers on the ground. For, the most part, we posit that teachers have not embraced the use of technology (Brendan, McGarr & McCormack, 2020).

In most cases, teachers' education programs lack modules concerned with the process of creating digital educational games. Lidor et al, (2013) point out that the average part of what is often called “planning, organization, management, and appraisal of learning” in education colleges comprises just18% of the curriculum. They argued that even when there is a reference to the development of online games this is haphazard and conducted according to initiatives of a particular lecturer. More often than not, this important aspect of pre-service education may be an appendage to courses about study planning or the integration of digital tools into teaching. Previous research found a correlation between the practical experience of the education student in this field, and their initiative toward integrating digital games as part of their classes in practice (Eyal, 2015).

The main aim of the present work is to contribute to the existing theoretical and practical knowledge in the context of teacher training to cultivate lifelong learning skills and 21st-century skills. These, we posit, will develop much-needed higher-order thinking skills while experiencing doing-based learning. We will further argue that to achieve this, it is important to empower teachers to approach these aspects of their practice from a positive perspective.

**Research questions**

The study aims to examine the influence of the training of pre-service teachers on teacher attitude towards the integration of digital games into education. We examine attitudes of pre-service teachers who possess technological-pedagogical knowledge, as well as their views on games as potentially developing high-order thinking and lifelong learning. This study further examines whether educational experience in the integration of digital games affects these variables. Our underlying assumption is that those pre-service teachers who had **learned** about the integration of games in education will present more positive opinions concerning all variables than pre-service teachers who had not. Likewise, pre-service teachers who had **taught** using the development of digital games in the trial classroom will have a more positive opinion about all variables than those who had neither **learned nor taught** games instruction

Therefore, this study seeks to answer the following research questions:

What are the connections between the perceived technological-pedagogical knowledge regarding digital games, opinions concerning the use of digital games, and lifelong learning skills of pre-service teachers?

1. What are the differences between pre-service teachers that **learned about** digital games and pre- service teachers who **had not learned as regards** technical-pedagogical knowledge, beliefs about thought development, and life skills in the context of the integration of digital games in the classroom?
2. What are the differences between pre-service teachers who have **taught** using digital games and those that **have not taught**, as regards technical-pedagogical knowledge, beliefs about thought development, and life skills in the context of the integration of digital games in the classroom?

**Methodology**

This study adopts a mixed-method research approach, drawing upon a quantitative method with several complementary qualitative questions. Through a 2x2 research array between participants, they could learn or not learn about digital games, and could have taught or not taught the subject. Data for all research questions was collected from an online questionnaire distributed to groups of students , the demographics of which will be elucidated below.

***Sampling***

Participants included 108 pre-service teachers from the Regev Excellence Program (44% of the sampling) and (55.6%) of participants were from standard education teacher training programs. The survey had an answer rate of 83%. 80% of whom were women. 69% of those surveyed were aged between 18-25. A further 20% were between 26-30, while the remaining 11% were above 30. The sample showed that 28.1% **had not learned** about digital games at all, while 71.9% **had learned** either through several classes or a full course about digital games. Among participants, 59.3% **taught** digital game development during their teaching practicum while 40.7% **did not**.

***Research tools***

The survey includes open and closed questions. The closed questions are divided into several clusters:

(1) Demographic questions (age, gender, sector association, college, and specialization).

(2) Teacher knowledge level - 7 items aim to estimate the personal knowledge levels based on the TPACK model of the pre-service teachers themselves (Mishra & Koehler, 2006; Crippen & Archambault, 2009). i.e. "I know how to choose online games that contribute to my students' learning"; "I know how to teach integrated online games lessons in my field of teaching".

(3) Attitudes -11 items regarding attitudes towards the use of digital games for teaching and learning. I.e., "the use of digital games improves my teaching".

(4) High order thinking strategies - 13 items representing the importance of digital games in developing a variety of high order thinking strategies such as comparison, asking questions, representing knowledge, argumentation, etc.

(5) Cognitive level- 6 items aim to measure the attitude toward the ability of digital games in developing high and low thinking levels according to Bloom's taxonomy, i.e., from 'knowledge' (low level of thinking) to 'evaluation' (high level of thinking).

(6) Lifelong learning skills- 13 items dealing with acquiring lifelong learning skills defined by OECD (Ananiadou & Claro,2009). i.e., Teamwork, Problem-solving, creative thinking.

The internal reliability by Cronbach’s alpha is satisfactory and is presented in Table 1.

The survey also included eight open-ended questions for descriptions of attempts to integrate digital games in teaching such as challenges faced, and plans.

**Findings**

To answer the first research question, correlations were calculated for the variables of the study. Table 1 presents the correlations of the research variables - perceived technological-pedagogical knowledge, opinions concerning the use of digital games, and lifelong learning skills.

Table 1. Correlation between perceived technological-pedagogical knowledge, attitudes concerning the use of digital games, and their influence on lifelong learning skills with all participants (n=108).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Attitudes (1) | 0.67 |  |  |  |  |  |  |  |
| Knowledge (2) | .33\*\*\* | 0.90 |  |  |  |  |  |  |
| Thought Processes (3) | .41\*\*\* | .47\*\*\* | 0.81 |  |  |  |  |  |
| Ways of Working (4) | .37\*\*\* | .40\*\*\* | .71\*\*\* | 0.70 |  |  |  |  |
| Life Skills (5) | .38\*\*\* | .36\*\*\* | .78\*\*\* | .66\*\*\* | 0.64 |  |  |  |
| Tools (6) | .22\*\*\* | .43\*\*\* | .59\*\*\* | .42\*\*\* | .43\*\*\* | 0.76 |  |  |
| Low-order Thought-Bloom (7) | .36\*\*\* | .32\*\*\* | .59\*\*\* | .53\*\*\* | .53\*\*\* | .43\*\*\* | 0.74 |  |
| High-order Thought-Bloom (8) | .35\*\*\* | .34\*\*\* | .62\*\*\* | .49\*\*\* | .62\*\*\* | .39\*\*\* | .65\*\*\* | 0.84 |

Note: Reliability of research variables according to Cronbach’s alpha is presented on the diagonal.

\*\*\*p<.001

As seen in Table 1, there are positive correlations between the research variables. Higher technological-pedagogical variables correlate directly with higher results in opinions concerning digital games and their contribution to lifelong learning skill development.

The second and third research questions examine the differences between pre-service teachers that **learned about** digital game integration and those that **had not learned about** them, as well as those between pre-service teachers who had **taught** using digital game integration and those that **had not taught** using the same. To answer these questions, nine 2-ways ANOVA analyses were conducted concerning the relevant variables. Table 2 presents these analyses.

Table 2. Differences between pre-service teachers that learned or did not learn, and those that taught or have not taught, concerning perceived technological-pedagogical knowledge, attitudes regarding the use of digital games, and their influence on lifelong learning skills development.

| Research Variable | Taught? | Did not learn | Learned | Total | Main effect- Learned F(1,104)  **(Eta2)** | Main effect- Taught  F(1,104)  **(Eta2)** | Interaction Effect F(1,104)  **(Eta2)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Attitudes | Did Not Teach | 3.19  (.48) | 3.67  (.38) | 3.53  (.46) | 7.65\*\*  (0.07) | 14.98\*\*\*  (0.13) | 5.41\*  (0.05) |
| Did Teach | 3.77  (.44) | 3.81  (.45) | 3.80  (.45) |  |  |  |
| Total | 3.53  (.54) | 3.76  (.43) | 3.69  (.47) |  |  |  |
| Knowledge | Did Not Teach | 2.88  (.71) | 3.41  (.86) | 3.25  (.85) | 3.99\*  (0.04) | 37.50\*\*\*  (0.27) | 2.04  (0.02) |
| Did Teach | 4.04  (.54) | 4.13  (.65) | 4.10  (.63) |  |  |  |
| Total | 3.55  (.84) | 3.84  (.82) | 3.76  (.83) |  |  |  |
| Thought Processes | Did Not Teach | 4.08  (.49) | 3.95  (.73) | 3.99  (.67) | 0.52  (0.05) | 9.42\*\*  (0.08) | 3.22^  (0.03) |
| Did Teach | 4.23  (.48) | 4.54  (.47) | 4.45  (.49) |  |  |  |
| Total | 4.17  (.48) | 4.30  (.66) | 4.26  (.61) |  |  |  |
| Ways of Working | Did Not Teach | 3.75  (.76) | 3.65  (.87) | 3.67  (.84) | 0.37  (0.01) | 13.69\*\*\*  (0.12) | 1.58  (0.02) |
| Did Teach | 4.11  (.54) | 4.39  (.59) | 4.31  (.59) |  |  |  |
| Total | 3.96  (.65) | 4.09  (.80) | 4.05  (.76) |  |  |  |
| Life Skills | Did Not Teach | 3.88  (.58) | 3.76  (.83) | 3.80  (.76) | 0.67  (0.01) | 6.35\*  (0.06) | 2.61  (0.03) |
| Did Teach | 4.03  (.78) | 4.41  (.69) | 4.30  (.73) |  |  |  |
| Total | 3.97  (.69) | 4.15  (.81) | 4.10  (.78) |  |  |  |
| Tools | Did Not Teach | 4.27  (.70) | 4.37  (.86) | 4.34  (.53) | 1.93  (0.02) | 1.74  (0.02) | 0.45  (0.01) |
| Did Teach | 4.36  (.48) | 4.66  (.54) | 4.57  (.53) |  |  |  |
| Total | 4.32  (.57) | 4.54  (.69) | 4.48  (.66) |  |  |  |
| Low-order Thinking - Bloom | Did Not Teach | 4.10  (.57) | 4.02  (.64) | 4.04  (.61) | 2.17  (0.02) | 5.45\*  (0.05) | 4.48\*  (0.04) |
| Did Teach | 4.13  (.53) | 4.58  (.56) | 4.45  (.59) |  |  |  |
| Total | 4.12  (.53) | 4.36  (.65) | 4.29  (.63) |  |  |  |
| High-order Thinking - Bloom | Did Not Teach | 4.03  (.74) | 3.80  (.80) | 3.86  (.78) | 1.81  (0.02) | 1.82  (0.02) | 7.75\*\*  (0.07) |
| Did Teach | 3.80  (.88) | 4.46  (.63) | 4.27  (.76) |  |  |  |
| Total | 3.89  (.82) | 4.19  (.77) | 4.10  (.79) |  |  |  |

^p<0.1, \*p<.05, \*\*p<.01, \*\*\*p<.001

Table 2 presents the findings from the analysis of the tests. They are as follows:

*Differences between the pre-service teachers* ***that learned*** *about teaching with digital games and those* ***that did not learn*** *about teaching with the use of digital games.*

There is a significant difference in the attitudes towards the use of technology and in the techno-pedagogical knowledge between the pre-service teachers who did not learn about teaching with digital games and those that learned about the use of digital games. The pre-service teachers who did learn about the use of digital games in instruction displayed a more positive attitude towards the use of games and they possessed more techno-pedagogical knowledge in comparison with those who did not learn about the use of digital games in instruction.

With this, as concerns the rest of the variables, there are no remarkable findings of other differences between the pre-service teachers that learned about and those that did not learn about the use of digital games for instruction.

*Differences between the pre-service teachers* ***that taught their subject*** *with digital games and those* ***that did not teach*** *their subject using digital games.*

The findings indicate many differences in several variables between the pre-service teachers who taught their subject through digital games as compared with those who did not teach their subject through the use and development of digital games. The pre-service teachers who taught their subject using digital games self-reported positive attitudes, self-perception of high knowledge of techno-pedagogy, a positive attitude towards the potential of digital games to cultivate ways of low-order thinking and to cultivate ways of working and lifelong skills. All this is relative to the pre-service teachers that did not teach their subject through the development of digital games.

The findings truly reflect differences within the groups that believe that the integration of digital games can cultivate lower-level thinking. However, there were no differences detected in the group that believes that digital games can cultivate higher-level thinking.

*The* ***combined*** *influence of* ***learning about*** *the integration of games and the* ***teaching of the subject*** *through games.*

The next section presents the interactions that were found.

**Attitudes towards the use of digital games**:research indicates that the pre-service teachers who learned through the direct experience of using digital games to teach displayed more positive attitudes towards their integration, regardless of whether they participated in a course on the topic or if they did not. Pre-service teachers who took a course on the integration of games in education, but who did not themselves integrate games into their teaching exhibited lower positive attitudes than those who had learned through first-hand experience. Pre-service teachers who did not learn about education using digital games and did not teach themselves the topic, displayed the most negative attitudes towards the use of digital games.

**Low and High order thinking:** the pattern of interaction between learning the topic (as a student) and teaching it actively (the pre-service teachers who taught using games) indicates that those who both learned and taught believe more strongly that integrating games into learning facilitates the ability to practice both lower and higher-level thinking relative to the other pre-service teachers in the other groups (i.e., those who learned but did not teach, neither learned nor taught, taught but did not learn).

As regards the fourth research question, all of the questions on the questionnaire were open-ended and the respondents who taught the subject using digital tools were asked to comment on the advantages and challenges they faced when teaching with digital tools. Qualitative coding of **descriptive words used to characterize the experience of the learners in the lessons in which the pre-service teachers integrated digital games** bear the fruit of the findings presented in Table 3.

Table 3. Frequency of words that describe the learners' positive experience in the integration of digital games.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Words used to describe a lesson that integrated games** | **Frequency in the answers (64)** | **Percent** |
| Factors of climate in the classroom | Fun/experience/enjoyment | 13 | 20.3 |
| Dynamism/enthusiasm / effervescence | 11 | 17.2 |
| Motivation/Willingness | 10 | 15.6 |
| Participation/active learning | 8 | 12.5 |
| Collaboration/group work | 8 | 12.5 |
| Curiosity/interest/light in their eyes | 6 | 9.40 |
| Cognitive  factors | Challenge/creativity | 3 | 4.67 |
| Understanding demonstration / focus | 3 | 4.67 |
| Independent learning | 2 | 3.12 |

As can be seen in Table 3, most of the words (87.5%) that the pre-service teachers chose to describe deal with the climate in the classroom and a small number (12.5%) to the positive contribution to the cognitive factors in learning.

**Summary and discussion**

The purpose of this study was to investigate the influence of elements of pre-service teacher training: to learn about the integration of digital games in teaching and practice trial teaching using digital games, as well as the attitudes of pre-service teachers towards this combination in connection with higher-order thinking and lifelong learning. To answer the research objective a quantitative quasi-experimental methodology was used which also included a qualitative aspect that provided additional details.

***Attitudes & experience as regards digital games***

The experience of pre-service teachers in their integration of digital games in subject teaching is more meaningful than their learning about digital games in training or a course. Learning about digital games without the opportunity to put that knowledge into practice improved their attitudes. However, the combination of learning about the topic and the opportunity to apply it to their teaching demonstrated the most positive influence on the attitudes of the respondents. These findings are consistent with the experiential learning cycle of Kolbe's (Kolb, 1984). \*

***Techno-pedagogical knowledge***

Pre-service teachers who took a course that specifically taught the integration of games reported a higher level of knowledge than those who did not take such a course. Similarly, the pre-service teachers who incorporated digital games into their teaching reported a higher level of techno-pedagogical knowledge than their counterparts who did not teach. However, a connection was not found between the learning and the teaching. This may indicate that it is not necessary to take a course to learn and to teach using digital games to obtain techno-pedagogical knowledge— either one will suffice. Regarding the ability to plan/teach a lesson and the knowledge of how to wisely integrate digital games into learning, we see that amongst those who learned the topic the only difference lies in their training. For those who had taught in the class using games, the components are high for all the measures. Likewise, there was no difference in knowledge found between those who learned the topic and those who taught in the class. Accordingly, pre-service teachers who taught using games believe that they can prepare lessons and lead their colleagues in integrating digital games into their lessons, and they further believe that they have the knowledge necessary to widely integrate digital games into teaching.

***Lifelong learning***

There is no difference in any area between those who learned and those who taught. However, there is a difference regarding lifelong literacy between those who taught using digital games and those who did not (but there is no difference as regards digital literacy). Those who taught using digital games reported that the life skills of their students improved as a result. As there was no change in the students’ level of literacy, we can conclude that learning through games does not improve computer literacy or the ability to process information.

***Lower and higher-order thinking***

There is no discrepancy between those who learned about incorporating games into their teaching and those who taught using games regarding their attitudes about whether digital games develop higher or lower thinking skills. Notwithstanding, those who taught using digital games reported that although the games developed lower-order thinking skills, they did not develop higher-order thinking skills.

Nevertheless, the investigation of the pattern of interaction between learning and teaching revealed that those who both learned and taught believe more strongly that the use of games in learning develops higher and lower order thinking skills more than the pre-service teachers in the other groups (i.e., learned but did not teach, neither learned nor taught, did not learn but taught).

In other words, if we want the pre-service teachers to believe that digital games develop higher order thinking, it is important for them to learn how to incorporate games into teaching and to have the opportunity to practice applying that knowledge (Cohen, Misher-Tal, Liba, 2018; Deckard et al., 2013, Deater-Deckard, Yang & Chang, 2013).

In summary, the findings highlight the importance of pre-service teachers receiving training on how to incorporate digital games into their teaching practices. The findings further indicate that it is preferable for pre-service teachers to undergo both general and specific training on how to use digital games as an effective teaching tool. Likewise, we recommend that those who organize the training courses investigate how pre-service teachers integrate digital games as a part of their practicum, and afterward as working teachers.

**Limitations of the research**

In the present research, the pre-service teachers chose if they would teach with digital games. Future research should investigate the extent to which the choice to participate in training influences a more positive attitude among the pre-service teachers. An experimental research paradigm, wherein the participants are divided into four respective groups may result in a causative inference, deduction, or conclusion as regards the connection between the training of the pre-service teachers to their positions and orientation regarding the integration of digital games in instruction. In addition, it is preferable to investigate the ways and consequences of using a constructivist approach for the development of games as a part of the learning process in depth.

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