PRE-SERVICE TEACHERS' PREPARATION AS A CATALYST FOR THE ACCEPTANCE OF DIGITAL TOOLS FOR TEACHING MATHEMATICS AND SCIENCE

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The present research examines whether the pre-service teachers' preparation in using digital tools in their teaching develops their acceptance of these tools as teaching tools. Here, acceptance is measured in terms of the constructs of the technology acceptance model (TAM) introduced by Davis. It also examines the mediation of self-efficacy, anxiety of using digital tools for teaching mathematics and science and enjoyment of this use between the constructs of acceptance of digital tools for teaching. We used questionnaires that are part of TAM. Forty eight mathematics and science pre-service teachers participated in the study. We analyzed the collected data using SPSS 21. The research results indicate that the pre-service teachers' preparation resulted in significant differences in their scores of affective and usage constructs associated with their acceptance of digital tools for mathematics and science teaching, except in the scores of anxiety.

Keywords: Pre-service teachers, preparation model, digital tools, mathematics, science

INTRODUCTION

A main factor in the use of technological tools in the mathematics classroom is the teacher (Thomas & Palmer, 2014), which necessitates educating pre-service teachers in using these tools in their teaching in the training schools. This education would encourage them to use these tools in their future teaching of the subject matter. In the present paper, we describe a model for preparing pre-service teachers in the use of digital tools in teaching and the effect of this preparation on some affective and behavioral aspects of the usage of these tools in the classroom. Two of the factors that affect teachers' use of technological tools in their teaching are their orientations towards this use and the value of this use (Thomas & Palmer, 2014). In the present research, we are interested in the previous two constructs, among other constructs, as constructs that could affect teachers' use of digital tools in the classroom. We utilize the Technology Acceptance Model (TAM) of Davis (1989) as a framework for such analysis. We are aware that other frameworks could be used to analyze the studied issue (e.g., Getenet, Beswick & Callingham, 2015), but we chose the TAM framework because it suits the analysis of the acceptance of digital tools for teaching the subject matter, which is one aspect of pedagogical technological knowledge (PTK) (Hong & Thomas, 2006).

Technology Acceptance Model (TAM)

One of the most widely used models for technology adoption and usage is the 'Technology Acceptance Model' (TAM) developed by Davis (1989). TAM assumes that perceived ease-of-use (PEOU) and perceived usefulness (PU) determine the user's acceptance of a technology. Davis describes PEOU as the degree to which the user expects the technology to be free of effort, while PU is the individual's subjective perception of the technology as increasing performance within an organizational context. As shown in Figure 1, TAM suggests that the user's actual usage of a particular system develops over four stages, where external variables as individual abilities and situational constraints influence technology usage through their impact on the PEOU and PU. Both factors affect a user's attitude towards the technology, which in turn influences the user's intention to use the technology. Furthermore, there is a direct impact of perceived usefulness on the user's intention to use the technology, which could mean that even if the individual has a negative attitude towards a technology, this could be overcome by a positive belief about the technology's usefulness, which finally leads to a positive usage intention (Röcker, 2009).

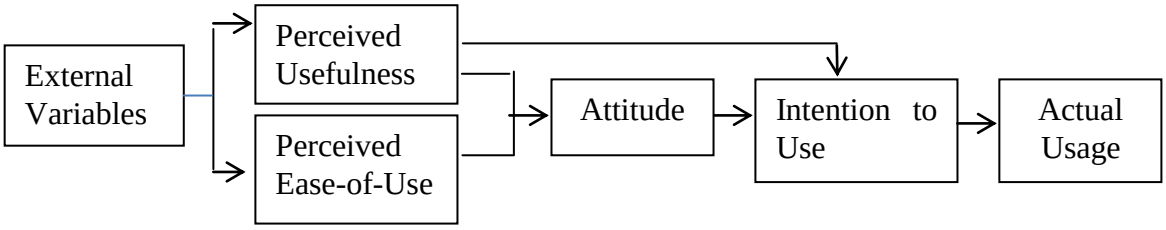

Figure 1: Original Technology Acceptance Model as in Davis et al. (1989)

Alenezi, Karim and Veloo (2010) added 'enjoyment', 'computer anxiety', 'computer self-efficacy' (CSE) and 'internet experience' to PEOU and PU to explain users' attitudes towards using E-learning. They found that computer anxiety, CSE and Enjoyment significantly influenced students' intention to use E-learning, while the Internet experience insignificantly influenced them. Alenezi et al. (2010), in contrast to Shih and Huang (2009), found that attitude was confirmed to mediate the relationship between PU, PEOU and the users' behavioral intention. Results from Yi and Hwang (2003) highlighted the important roles of self-efficacy, enjoyment, and learning goals orientation in determining the actual use of web-based information systems. In the present research, we examined whether self-efficacy, enjoyment and anxiety mediate between the constructs of accepting digital tools for teaching mathematics and science.

Research rationale and goals

Different studies examined students' acceptance of technological tools, but little research examined pre-service teachers' acceptance of digital tools for mathematics and science teaching, as a result of their preparation, especially when affective constructs are considered as mediators for this acceptance. The present study attempts to do so, considering self-efficacy, enjoyment and anxiety as personal constructs that could mediate between the constructs of pre-service teachers' acceptance of using digital tools in their teaching. Doing so, one of the present study goals is to examine whether pre-service teachers' preparation develops their acceptance of these tools as teaching tools. Here,

acceptance is measured in terms of the TAM components, i.e. PEOU, PU, CSE, attitude and future use. As mentioned above, another goal is to examine the mediation of self-efficacy, anxiety of using digital tools for teaching and enjoyment of this use between the constructs of the pre-service teachers' acceptance of digital tools for their teaching.

Research questions

1. Does the preparation of pre-service teachers in the use of digital tools increase their acceptance of these tools for teaching mathematics and science?

2. Does the preparation result in significant differences in the scores of the different constructs of pre-service teachers' acceptance of digital tools (for teaching mathematics and science) according to the pre-service teachers' specialization, computer-ability and computer-use?

3. Do CSE, anxiety of using digital tools for teaching mathematics and science and enjoyment of this use mediate between PEOU and PU on one side and attitude towards this use on the other side?
4. Do CSE, anxiety of using digital tools for teaching mathematics and science and enjoyment of this use mediate between attitude towards this use on one side and intention to use on the other side?

METHODOLOGY

Research context and participants

The current research accompanies the preparation of third year pre-service teachers to use digital tools effectively in teaching mathematics and science. The preparation of the pre-service teachers in the college lasts four years, where the third year is the year in which the pre-service teachers are prepared to use digital tools in their teaching in the training schools. In their first year, the pre-service teachers participate in a course that focuses on technological skills as skills to use editors and spreadsheets. In their second year, the pre-service teachers participate in a course that focuses on integrating technology in teaching the discipline, as mathematics or science.

We administered questionnaires to measure the advancement of the pre-service teachers' acceptance of digital tools in teaching mathematics and science. Forty eight pre-service teachers majoring in mathematics and science teaching (twenty four in each discipline) completed the questionnaires at the beginning and end of the preparation.

Research instruments

The questionnaire is based on Davis' Technology Acceptance Model (Davis, 1989), with 7-point Likert items, was composed to conduct the research. Since TAM variations in different previous studies were all reliable, factor analysis was not carried out in this study. Instead, face validity and reliability (Cronbach's Alpha) calculations were carried out. The six following scales were used: digital tools usefulness (9 items), digital tools self-efficacy (5 items), digital tools ease-of-use (3 items), attitude towards digital tools (3 items), intention-to-use and use of digital tools (3 items).

The added constructs (self-efficacy, enjoyment and anxiety were taken from Alenezi, Karim and Veloo (2010).

Statistical exams

The questionnaire had two parts. The first part collected personal information as specialization, computer-ability, and computer-use, while the second part was composed of the six scales. The questionnaire was translated for the first time to Arabic language before administering them to the pre-service teachers. The questionnaire underwent validity and reliability exam.

Face validity: The Arabic translation of the questionnaire was given to a group of pre-service teachers who were required to examine if the scales' statements were understandable to the reader. Some items of the scales were restated to clarify their ambiguity.

Content validity: The questionnaire was given to a group of experts (five college pre-service teachers) who were required to examine whether the questionnaires' items cover the full domain of the different educational constructs and whether they cover constructs other than the appropriate ones. The experts gave no remarks that necessitated the modification of the TAM questionnaire.

The scales' reliability: The scores of the pre-service teachers in the TAM questionnaires were used to compute Cronbach alpha of the various TAM constructs. The computations resulted in values

that ranged between .82 and .91, which are considered acceptable reliability scores.

Data processing: Research question 1 was answered using paired-samples t-test. Research question 2 was answered using ANOVA. Research questions 3 and 4 were answered using the four steps of Baron and Kenny (1986).

RESULTS

The preparation model:

The pre-service teachers' preparation utilized a community of inquiry pedagogy (Jaworski, 2005) as well as practice-based or practice-oriented view of professional development (Ball & Bass, 2003; Ponte, 2012). The utilization of the two previous frameworks targeted developing mathematics and science pre-service teachers' practice in working with digital tools for teaching. More specifically, it targeted developing pre-service teachers' selection of a digital tool for a specific topic, in addition to teaching a specific topic with the selected digital tool.

The preparation model depended on the interaction between the pre-service teachers in an electronic forum designed for discussing the selection of digital tools for specific topics, utilizing them in lesson plans and implementing them in the mathematics and science classrooms. The four authors of the paper functioned as educators of the pre-service teachers in the forums, discussing with them issues that the pre-service teachers or the educators raised. The discussion also happened at office hours between the pre-service teachers and their educators.

Moreover, the pre-service teachers' preparation concentrated on two aspects. First, knowing the tool technically (technological knowledge) and pedagogically (pedagogical knowledge) and being able to suggest it for teaching a mathematical or scientific content (one aspect of PTK). Second, being able to start from a specific content, and select and integrate appropriate digital tools for its teaching (another aspect of PTK). In more detail, each pre-service teacher had to learn at least two digital tools technically by himself/herself and prepare user guides (PDF file or digital book) for other teachers that include description of the most significant operations in these digital tools. Furthermore, the pre-service teacher had to record video clips of screen shots while performing operations in these digital tools in order to explain for the users how to perform these operations.

Moreover, each pre-service teacher was required to prepare pedagogical materials of how to use the digital tools in teaching mathematics or science, and then present the materials in the training workshop and afterwards in the electronic forum. Following that, all the materials were uploaded to internet sites that were constructed by the pre-service teachers. An internet site was constructed by the pre-service teachers' educators that included all the materials prepared by the pre-service teachers, where these materials constituted a data bank for digital tools. In addition, each pre-service teacher was requested to prepare at least two lessons for teaching mathematics or science using three digital tools from the data bank. These lessons had to involve also collaborative learning and investigations that encourage the use of higher order thinking skills. In addition, each pre-service teacher chose a subject in a digital textbook for teaching mathematics or science, and added layers on it that connect to pedagogical activities based on using digital tools from the data bank site. All these issues were discussed by all the pre-service teachers in the electronic forum, as well as in the office hours of the pre-service teachers' educators.

All this happened in the first semester. In the second semester, the pre-service teachers were asked to experiment with the prepared materials and lessons in their training schools, reflect on their

experimenting and then improve the lesson plans they built before. All the previous steps were practice-based and intended to develop the actual practice of the pre-service teachers of using digital tools in the science and mathematics classroom. Figure 2 describes the teachers' preparation model that we followed to encourage the pre-service teachers to adopt digital tools for teaching mathematics and science.

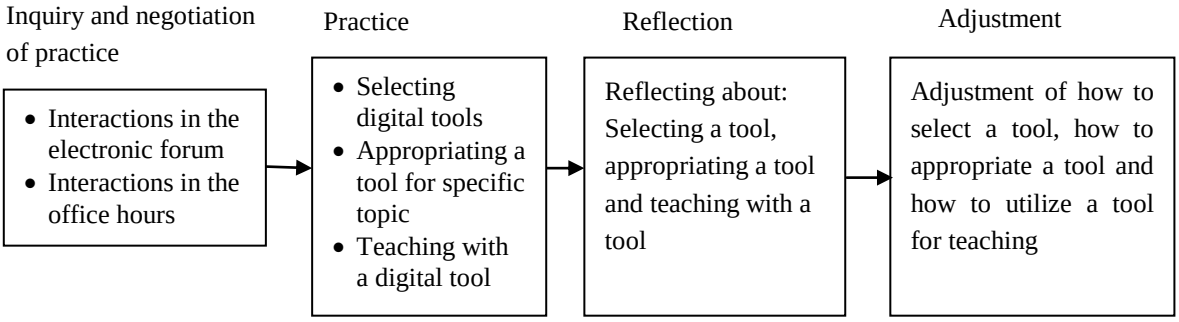

Figure 2: Teachers' preparation model for adopting digital tools for teaching

The effect of the preparation model on the participating pre-service teachers' acceptance of digital tools for mathematics and science teaching

The present research examined the influence of using a specific model (described in the methods section) to prepare pre-service teachers for using digital tools through one academic year. Doing so, we computed means and standard deviations of the scores of the different constructs of acceptance digital tools for mathematics and science teaching. We also ran paired t-test to examine whether the differences between the scores before and after the intervention are significant. Table 1 shows the results of the previous computations.

Table 1: Means, standard deviations, T value of the scores of the different constructs of acceptance of digital tools for mathematics teaching (N=48)

Category	Pre-Mean (SD)	Post- Mean (SD)	T value
Ease of use	5.23 (1.29)	6.05 (1.13)	5.31***
Usefulness	5.69 (1.11)	6.15 (1.11)	2.80**
Attitude	5.72 (1.19)	6.18 (1.13)	2.82**
Intention to use	5.83 (1.11)	6.18 (1.20)	2.39*
Use	5.14 (1.48)	6.18 (1.18)	4.21***
Self-efficacy	5.80 (1.13)	6.16 (1.15)	2.23*
Anxiety	3.00 (1.83)	3.33 (2.28)	0.79
Enjoyment	5.71 (1.31)	6.15 (1.20)	2.58*

*p<.05, **p<.01, ***p<0.001

Table 1 shows that using a specific model (described in the methods section) to prepare pre-service teachers for using digital tools through one academic year resulted in significant differences in the scores of the different components of the technology acceptance model used in the present research, except in the scores of anxiety.

We measured the effect size related to the differences that resulted from the intervention, using Cohen's (1988), where 0.8 is considered a large effect size, 0.5 is considered a medium effect size and 0.2 a weak one. Doing so, we found that the effect size of the intervention for "ease of use" (d = 0.78) was found to be a large effect, while the effect size of the intervention for "usefulness" (0.405), "use" (0.406) and "intention to use" (0.607) were found to be medium effects. In addition, the effect size of the intervention for "attitude" (0.33), "self-efficacy" (0.33) and "enjoyment" (0.37) were found to be weak effects.

Another goal of the present research was to examine whether the independent variables (specialization, computer-ability, and computer-use) influenced the results of the intervention. Doing so, we ran mixed way ANOVA which showed no significant interaction at the level of 0.05 or lower.

A third goal of the present study was to examine the mediation of enjoyment, anxiety and self-efficacy between the predictors ease-of-use and usefulness, and the outcomes attitude and use. At the beginning, Pearson correlations were computed, which showed non-significant correlations with anxiety. So, anxiety was not considered as mediator construct. Moreover, self-efficacy and enjoyment were examined as mediators between ease-of-use and usefulness and between attitudes (First mediation). Afterwards, self-efficacy and enjoyment were examined as mediators between attitude and the intention to use digital tools in teaching (second mediation).

In Step 1 of examining the first mediation, the regression of attitude as outcome on the predictors, ease of use and usefulness scores, ignoring the mediator, was significant, b =.94, t(47) = 1.71, p =.000 for ease of use and b=0.96, t(47)=24.28, p=0.000 for usefulness. Step 2 showed that the regression of the mediators' scores, self-efficacy and enjoyment, on the predictors, was also significant, b = 0.91, t(47) = 15.22, p =.000 for self-efficacy on ease-of-use; b = .97, t(47) = 26.35, p =.000 for self-efficacy on usefulness; b = .92, t(47) = 16.13, p =.000 for enjoyment on ease-of-use; b = .97, t(47) = 28.39, p =.000 for enjoyment on usefulness. Step 3 of the mediation process showed that the regression of attitude scores on the mediators was also significant, b=.96, t(47)=24.19, p=.000 on self-efficacy and b=.95, t(47)=20.39, p=.000 on enjoyment. Step 4 of the mediation process showed that the regression of the attitude on the ease-of-use controlling for enjoyment as a mediator was also significant, b =.46, t(47) = 4.57, p =.000. This shows partial mediation of enjoyment as the effect of ease-of-use has dropped from .94 to .46. Partial mediation was obtained too for self-efficacy as mediator between attitude and ease-of-use, b =.39, t(47) = 4.81, p =.000, where the effect of ease-of-use has dropped from .94 to .39. The same computations in step 4 were carried out for the mediators between attitude, as outcome, and usefulness, as predictor. These computations showed partial mediation regarding self-efficacy and no mediation regarding enjoyment.

As to the second mediation, computing for mediation effects for intention to use as outcome and attitude towards use as predictor, the first three steps showed significant results for self-efficacy and enjoyment as mediators. Step 4 showed partial mediation of self-efficacy, where the effect of attitude on the intention to use has dropped from .95 to .31. It also showed partial mediation of enjoyment, where the effect of attitude on the intention to use has dropped from .95 to .36. The previous results are illustrated in Figure 3.

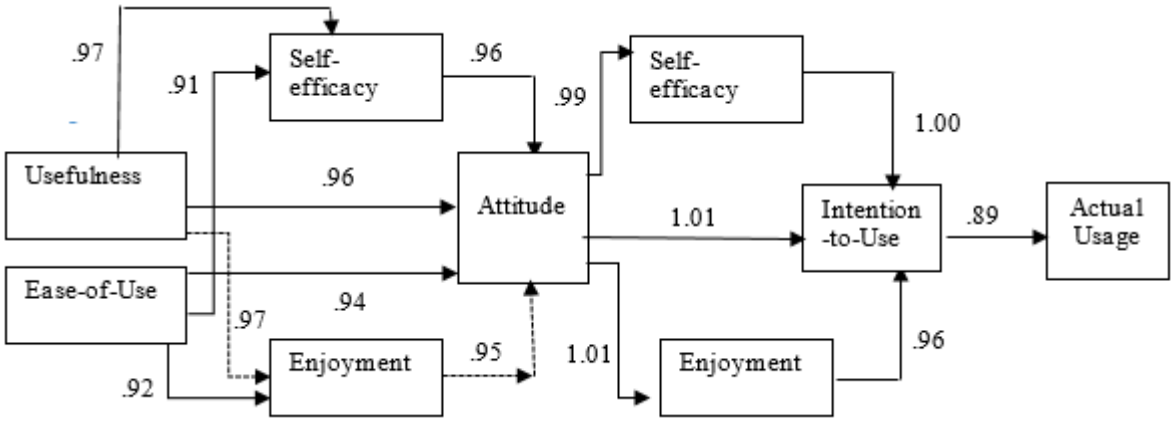

Figure 3: Regression analysis of the TAM constructs for pre-service teachers acceptance of digital tools for teaching

DISCUSSION AND CONCLUSIONS:

The present research examined the influence of using a specific model in the preparation of pre-service teachers for using digital tools through community of inquiry practices and practice-based professional development. The research results indicate that the preparation resulted in significant differences in the scores of the different constructs, except anxiety, of the acceptance of digital tools for teaching mathematics and science. These results show the effectiveness of the community of inquiry practices (Jaworski, 2005) regarding the acceptance of technology for teaching, where these practices included synchronous as well as asynchronous means of communication. It is our conclusion that both means are essential in pre-service teachers' education. The results also show the effectiveness of practice-based professional development (Ball & Bass, 2003) which included the two effective means (Spector et al., 2008): pre-service teachers' access to the digital tools, and the opportunities they had during the preparation year to utilize these tools in their teaching. Regarding the insignificant differences in the scores of anxiety, these scores were already low before the preparation as a result of the pre-service teachers' preparation in their first two years of study, so it is natural that they stayed low after the preparation.

Running mixed way ANOVA showed that the independent variables (specialization, computer-ability, computer-use) did not interact significantly with the intervention. This insignificant interaction indicates that the intervention influenced positively all the pre-service teachers, and not only part of them. We expected that the intervention would benefit the science pre-service teachers more because the mathematics pre-service teachers who are specialized in computers too. It seems that this did not happen because the intervention was involved with technological pedagogical content knowledge which was developed in the two groups of pre-serves teachers as a result of preparing them to integrate digital tools in teaching during one year. This has not much to do with the technological knowledge that the mathematics pre-service teachers are engaged with during their computer specialization.

The anxiety scores, being low, resulted in insignificant correlations with the other variables, what excluded anxiety from being a mediator between the variables of technology acceptance. Self-efficacy proved to be a partial mediator between ease-of-use and attitude, as well as between usefulness and attitude. Moreover, self-efficacy proved to be a partial mediator between attitude and intention-to-use. At the same time, enjoyment proved to be a partial mediator between ease-of-use and attitude, but not between usefulness and attitude. At the same time, enjoyment proved to be a partial mediator between attitude and intention-to-use. These results show the importance of paying attention to affective and psychological constructs as mediators or moderators between other constructs of pre-service and in-service teachers' acceptance of technological tools for teaching. Thomas and Palmer (2014) studied the teachers' confidence-to-use of technologies and their beliefs in the value of technology as constructs that affect their use of technological tools in teaching mathematics. Here self-efficacy is related to the confidence-to-use construct. Nevertheless, more attention to the various affective and psychological constructs are needed in order to study the issue of technology use in teaching mathematics and science, as well as teachers' education regarding this use.

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