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# **The development of pre-service teachers' TPACK for the use of digital tools**

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*The ministry of education is launching a national project to implement the use of ICT in the Israeli education system. To prepare pre-service teachers with whom we work for this kind of implementation, we designed a model, which supports them to learn to use digital tools effectively while integrating a particular pedagogy for teaching a specific mathematics or science content. The goal of the present research is to study the development of these pre-service teachers' Technological, Pedagogical and Content Knowledge (TPACK), attitudes toward computers and their ICT proficiency. For this purpose, we used and adapted questionnaires from different sources. The research results show significant improvement in the TPACK level and ICT proficiency, but no significant effect of the preparation on most of the components of the teachers' attitudes toward computers, being positively high before and after the preparation.*

*Keywords: Pre-service teachers, TPACK, digital tools, professional development.*

## **Introduction**

Shulman (1986) suggested the PCK (pedagogical content knowledge) model to represent the interaction of two types of teachers' knowledge: content knowledge and pedagogical knowledge. He proposed that this interaction be considered in order to understand teachers' expertise in teaching a particular subject matter. Various researchers (for example Koehler and Mishra, 2009; Niess et al., 2009), built on Shulman's PCK to describe the interaction of teachers' understanding of educational technologies with their PCK that results in effective teaching with technology. Specifically, they talked about the technological pedagogical and content knowledge of teachers (TPACK), where this model describes the interactions between and among the three main components of teachers' knowledge: content, pedagogy, and technology. These interactions result in new types of teachers' knowledge, namely PCK, TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK. In this paper, we describe the development of pre-service teachers' TPACK as a result of preparing them in the use of digital tools over one academic year.

## **Technological, Pedagogical and Content Knowledge**

Though some researchers consider TPACK too blunt an instrument (e.g., Clark-Wilson & Hoyles, 2016; Thomas & Palmer, 2014), other researchers refer to it when studying mathematics teacher's professional development (e.g., Balgalmis, Shafer, & Cakiroglu, 2013; Bowers & Stephens, 2011). Generally speaking, TPACK is the knowledge of how to integrate technology in teaching the subject matter. This knowledge also includes the appropriation between a specific technological tool, the teaching of a specific topic and being aware of the difference between various technological tools in teaching a specific topic. Further, this knowledge means being aware of students' problems of the subject matter that could be overcome by using specific technological tools. It also includes the

awareness of students' difficulties of the subject matter that result from using specific technological tools and how to overcome these problems (Koehler & Mishra, 2009).

Robova, and Vondrova (2015) studied mathematics teachers' awareness of the specific technological skills needed for their teaching (making functions visible on the screen, changing visual appearance of graphs, interpreting numerical results, using dynamic features of a tool) and their ability to design teaching which takes the specific skills into account. Furthermore, Koh and Divaharan (2011) described an instructional model for developing pre-service teachers' TPACK. We follow the previous attempts to suggest a preparation model for developing pre-service teachers' TPACK in utilizing digital tools in their teaching.

### **Pre-service teachers' attitudes toward computers**

Fishbein (1967) defined attitude as a learned tendency to respond to an object in a consistently favorable or unfavorable way. Other researchers (Zan & Di Martino, 2007) defined attitude in terms of emotions: a positive or negative emotional reaction toward a specific situation. These definitions show the possible influence of attitudes on behavior in general and on pre-service teachers' behavior in particular. Attention to attitudes has risen when ICT started to emerge as a possible tool for the improvement of teaching and learning. In this context, researchers found that these attitudes have major influence on the success and meaningful use of the ICT in their teaching (Albirini, 2006).

In our research, attention was given to pre-service teachers' attitudes toward computers, together with the development of their TPACK and ICT proficiency, as a consequence of their preparation in the use of digital tools. We used the 'teacher's attitudes toward computers' questionnaire (TAC) as it probes teachers' attitudes toward ICT use in teaching and their intention to do so (Baya'a & Daher, 2013). We were also interested in the pre-service teachers' proficiency level in ICT as an indicator of their intention to use ICT in their teaching as the proficiency variable is reported to affect teachers' readiness to use ICT in their teaching (Granger, Morbey, Owston & Wideman, 2002).

### **The research questions**

The main research question is: How will the preparation of pre-service teachers in the use of digital tools, according to the model that we designed, affect their TPACK level, ICT proficiency and their attitudes toward computers?

### **Research context, participants and the preparation model**

This current research accompanies the preparation of pre-service teachers to study how to use effectively digital tools in the mathematics or science classroom. This knowledge is the core of the TPACK model. We administered questionnaires to measure the advancement of the TPACK levels and attitudes toward computers of the pre-service teachers who implemented the model, as well as their ICT proficiency. Approximately 55 students majoring in mathematics and science teaching in intermediate schools completed the questionnaires at the beginning and end of the preparation. These students were in their third year of training alongside two courses that provided a background in the use of ICT for teaching mathematics and science.

The preparation model aimed to improve the pre-service teachers' selection of a suitable digital tool for a specific pedagogy and subject. It also tried to improve the integration of digital tools to teach some specific content. This preparation model concentrated on two aspects. First, knowing the tool technically and being able to adapt it to teach some specific content. Second, developing the ability to select and integrate suitable digital tools for some specific content and pedagogical method. In more detail, each pre-service teacher worked independently to learn to use at least two digital tools and to prepare user guides (as PDF file or digital book) that included descriptions of the most significant functions of these digital tools. Furthermore, the pre-service teachers were required to record video clips of screen shots while performing operations in these digital tools as explanations for another user. The pre-service teachers were asked to select the digital tools from a catalog of general digital tools prepared by the ministry of education in Israel. This catalog includes various digital tools that could be adapted for use in various subjects and levels, such as: Flipsnack for creating online digital books, Linoit for creating collaborative bulletin board, Socrative for personal and class assessment and Mindomo for creating mind maps.

Moreover, each pre-service teacher was required to prepare pedagogical materials on how to use the digital tools that she was engaged with in teaching mathematics or science, and then present the materials in the training workshop to receive comments from her peers and the pedagogical supervisor. Following that, the pre-service teacher reflected on her developed materials, adjusted it and uploaded all the materials to an internet site that was constructed by the pre-service teachers and the pedagogical supervisors. This internet site 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 and pick three digital tools from the catalog (including one that she was engaged with) to use them in her teaching. These lessons had to involve also collaborative investigations that encourage the use of higher order thinking skills. Finally, each pre-service teacher picked a subject from within a digital textbook for teaching mathematics or science, and added connections to pedagogical activities based on using digital tools from the data bank site.

During the first semester, the pre-service teachers had two options: to start from the digital tool and integrate it for teaching some specific content, or starting from the content and selecting a suitable digital tool to teach that content. In the second semester, each pre-service teacher was asked to experiment with the prepared materials and lessons in her training school with at least one of the chosen tools, and reflect on the experience. This reflection was on the actual implementation of the digital tool in the classroom environment, and it was posted in the data bank for digital tools for other pre-service teachers to consider as they selected digital tools for their own use.

## **Research instruments**

The research instruments included three questionnaires as follows: Questionnaire 1: Technological, Pedagogical, and Content Knowledge (TPACK) (revised) questionnaire, constructed on the basis of the TPACK instrument for pre-service teachers developed by Schmidt et al. (2009).

Questionnaire 2: Teachers' Attitudes toward Computers (TAC, v. 6.1) questionnaire: This questionnaire was tested by Christensen and Knezek (2009) who concluded that it is a well-validated and reliable instrument for teachers' self-appraisal of their attitudes toward computers.

Questionnaire 3: The Use of ICT in Colleges of Education (UICT): This questionnaire was developed by The MOFET Institute (A Center for the Research, Curriculum and Program Development in Teacher Education in Israel) to track the professional development of pre-service teachers' use of ICT. We used the ICT proficiency part of the questionnaire.

The validity of the questionnaires was considered by giving the Arabic translations to a group of pre-service teachers who were requested to examine if the questionnaires' statements were clear to the reader. As a result, some items of the questionnaires were rephrased to clarify their meaning.

The pre-service teachers' scores in the overall constructs and their categories, before the preparation and after it, were examined for internal reliability using Cronbach alpha. The results showed high Cronbach alpha (above 0.85 for all the categories and for the overall construct) indicating adequate internal reliability for the questionnaires and their categories. These results were expected due to the extensive use of these questionnaires in the literature.

## Data processing

Data was analysed using paired-samples t-test to determine if there were significant differences between scores of pre-service teachers in the various questionnaires before and after the preparation. Cohen's *d* (the ratio between the difference of the means and the average of the standard deviations) (Cohen, 1969) was used to compute effect sizes to assess the practical significance of results.

## Results

### Pre-service teachers' ICT proficiency

Table 1 shows the proficiency level of the pre-service teachers before and after the preparation (values between 1 to 5), as well as paired sample t-test between the two observations.

Outcome	Before Preparation		After Preparation		<i>t</i>	<i>d</i>
	M	SD	M	SD		
Score of ICT proficiency in UICT	3.80	0.56	4.20	0.59	4.17***	0.70

\*\*\*  $p < 0.001$

**Table 1: Means, standard deviations and t-test for pre-service teachers' ICT proficiency level (n=54)**

As displayed in Table 1, the results show that the pre-service teachers' ICT proficiency level differs significantly before and after the preparation. Large positive effect size of 0.70 was derived for the preparation on the pre-service teachers' ICT proficiency level. This advancement was mainly the result of the major improvement in their 'multimedia tools proficiency'.

### Pre-service teachers' TPACK level

The TPACK level comprised the total score of the TPACK questionnaire and six other scores for each partial type of knowledge for technology, pedagogy, content and intersections between them. Table 2 shows the TPACK components' scores of the pre-service teachers before and after the preparation (values between 1 to 5), as well as paired sample t-test between the two observations.

Outcome	Before Preparation		After Preparation		<i>t</i>	<i>d</i>
	M	SD	M	SD		
TPACK	3.93	0.53	4.50	0.46	8.19***	1.15
TK	3.90	0.63	4.44	0.59	6.31***	0.89
PK	4.04	0.52	4.57	0.46	6.35***	1.08
PCK	3.81	0.57	4.57	0.49	8.49***	1.43
TCK	3.78	0.76	4.45	0.52	7.02***	1.05
TPK	4.02	0.67	4.50	0.63	4.85***	0.74
TPCK	3.88	0.78	4.51	0.68	5.19***	0.86

\*\*\*  $p < 0.001$

**Table 2: Means, standard deviations and t-test for pre-service teachers' TPACK level (n=54)**

As displayed in Table 2, the pre-service teachers' scores in the components of TPACK differ significantly before the preparation and after it. Large positive effect sizes of 0.74 and more were derived for the preparation on the pre-service teachers' TPACK and its components.

### Pre-service teachers' attitudes toward computers

Attitudes toward computers were assessed using 9 categories. Table 3 shows components' scores of the pre-service teachers' attitudes toward computers before and after the preparation (values between 1 to 5, except perception 1 to 7), as well as paired sample t-test between the two observations.

Outcome	Before Preparation		After Preparation		<i>t</i>	<i>d</i>
	M	SD	M	SD		
TAC General	3.86	0.47	3.99	0.53	2.09*	0.26
Interest	4.37	0.64	4.32	0.74	-0.42	-0.07
Comfort	4.11	0.99	4.17	1.11	0.38	0.05
Accommodation	4.65	0.59	4.38	1.04	-1.86	-0.33
Interaction	3.82	0.90	4.19	0.87	2.53*	0.41
Concern	2.54	0.69	2.82	0.85	2.55*	0.36
Utility	4.29	0.51	4.39	0.74	1.01	0.16
Absorption	3.45	0.91	3.82	1.07	2.28*	0.37
Significance	4.18	0.67	4.27	0.78	0.88	0.12
Perception	5.60	1.06	5.79	1.19	1.25	0.16

\*  $p < 0.05$

**Table 3: Means, standard deviations and t-test for pre-service teachers' TAC level (n=54)**

As displayed in Table 3, the pre-service teachers' scores in the categories of attitudes toward computers differed significantly before the preparation and after it in the categories: interaction, concern, absorption and TAC general. In these constructs, a small effect size of 0.26 was derived for the preparation on the pre-service teachers' general TAC score, and moderate effect sizes of 0.41,

0.36 and 0.37 were derived for the preparation on the interaction, concern and absorption respectively.

## **Discussion and conclusions**

The research aimed to examine how the preparation course affected the pre-service teachers' ICT proficiency, TPACK level and their attitudes toward computers. The research results indicated several significant positive effects of the preparation model used in that preparation that related to the pre-service teachers' abilities and knowledge regarding the integration of digital tools in teaching.

### **Pre-service teachers' ICT proficiency**

The research results indicated significant improvement in the pre-service teachers' ICT proficiency as a consequence of the preparation, especially in multimedia tools proficiency. The mathematics and science pre-service teachers usually have high ICT proficiency, but the requirements in the preparation model led to significant improvement particularly in their multimedia proficiency. These results are due to a consideration of the technology knowledge related to the digital tools in the preparation process. This resulted in the pre-service teachers increased competence in their use of digital tools for personal and professional purposes, which caused them to feel confident to utilize new digital tools independently and individually (Prestridge, 2012), and thus improved significantly their ICT proficiency. This suggests that pre-service teachers need to be given the opportunities to work with technological tools in order to improve their ICT proficiency and their readiness to integrate ICT in their teaching (Muir-Herzig, 2004).

### **Pre-service teachers' TPACK level**

As a result of the preparation, the general TPACK level of the pre-service teachers, as well as its six partial types, were significantly improved. These results could be due to the attention of the pre-preparation model to the ability of the pre-service teachers to appropriate the digital tools pedagogically to teaching a specific content, and vice versa. It could be said that the pre-service teachers' diverse experiences in the workshop improved their knowledge in different types of knowledge related to their teaching mathematics or science. Thus, the preparation model provided the pre-service teachers with opportunities to maintain and shift their instructional approaches enriched with innovative educational technologies (Martin, 2015). This preparation model could be implemented worldwide when taking into consideration the particular background and conditions of the pre-service teachers involved.

### **Pre-service teachers' attitudes toward computers**

The results of this research show that following the preparation process, no significant improvement was detected in the pre-service teachers' attitudes toward computers for most of the TAC components, with exception of TAC general, interaction, concern and absorption. We should note that in both cases, before and after the preparation, the attitudes were very favorable toward computers.

As for the positive change in some attitudinal categories, such as absorption, the pre-service teachers had, during the workshop, the chance to be actually involved and improve their knowledge in computers and ICT. This might have improved their ability to solve problems related to the

computer use in the classroom; which encouraged them to insist to solve these problems, even the hard ones. This influence of teachers' experience in technology on their ability to solve technological problems is supported by DeLuca (1991) who claims that technological knowledge overcomes technological problems in the classroom. This could improve pre-service teachers' attitudes toward computers.

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