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Secondary teachers' subject matter expertise, pedagogical knowledge and digital skills: The 'Technological Pedagogical Content Knowledge' (TPACK) model

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Abstract

This paper presents the findings of a research conducted by secondary teachers in Greece, regarding their self-assessment upon subject matter expertise, pedagogical knowledge and digital skills. The quantitative data of the research were collected in the context of my postdoctoral research and outline the profile of Greek modern philologists' and their competence in various fields about professional development. The results illustrate that philologists self-assess highly on their subject matter competence, satisfactory on the pedagogical strategies they adopt in their educational practice and on their digital skills. Deficits, however, in relation to the "Technological Pedagogical Knowledge" (TPK) of secondary education teachers are observed. Finally, differences related to the gender, qualifications and work experience in teaching are identified.

Keywords: secondary teachers, content knowledge, pedagogical competence, digital skills, professional identity

1. Introduction

Professional teachers of all educational grades and specialties, wonder about the elements of their professional identity, which will contribute to the development of the educational process. However, in some cases modern teachers find it difficult to shape their professional identity as they teach in an "ill-structured" educational environment (Mishra & Koehler, 2006, p. 61). By the term "ill-structured" we often mean the non-organized field in which a teacher works. The deficits observed in education concern either the cognitive and pedagogical competence of the teachers or to their inability to teach "effectively", through flexible teaching models and theories, combining knowledge from different scientific fields (interdisciplinary), or in the educational system's shortcomings (Morrison et al., 2019).

The "relaxed" or otherwise, the "ill-structured" educational landscape may also be related to the meekness of teachers to "lead" their classrooms and reshape their educational practices (Lumpkin, Claxton & Wilson, 2016, p. 60-61). Teachers, in the face of such a situation, do not know where to focus and how to improve the profile of their modern students, their aptitudes and interests, the way they think, process information, discuss, shape perceptions, diffuse their ideas and reach knowledge. But why are teachers unable to cope with their multi-level role? This, in particular, may relate to the lack of professional qualifications (subject matter, pedagogical approaches) or even to the "incorrect" priorities that teachers set in their educational practice (Ingersoll, 2005, p. 175).

Research on the characteristics of modern teachers focuses on the concept of "identity" and, in particular, on the concept of "professional identity". These surveys focus on the characteristics acquired by the teachers throughout their professional career (Beijaard, Meijer & Verloop, 2004, p. 107-108). Of course, the importance that can be attached to the concept of teachers' professional

identity may vary. For example, relevant research sometimes focuses on teachers' perception of their instruction and profession and sometimes on how teachers evaluate their knowledge and skills in their professional development. On the other hand, many research focus on the priorities given by teachers, either in the strengthening of their identity through the acquisition of an adequate cognitive background, in the transmission of pedagogical skills or now, in modern times, in updating their digital knowledge and skills, tailored to the needs of their profession and, at the same time, to the interests of their students (Harris, Mishra & Koehler, 2009, p. 394-395).

2. Reflection on Pedagogical and Technological Content Knowledge

In the late 1990s, the educational psychologist Lee Shulman was concerned, in particular, about the knowledge and skills should be possessed by teachers. It rightly criticizes the mechanistic and "objective" - quantitative - way of assessing the formal qualifications of teachers and favors a different approach to the subject. Instead of assessing, unilaterally and fragments the competence of the teacher in each subject, Shulman puts on the "table" of the discussion the evaluation and competence of the teacher in pedagogical subjects, such as: the teacher's ability to understand the diversity of students, to acquire students intercultural sensitivity, for teachers to understand the needs of children, to manage situations in their classroom; to have knowledge of education policy issues, etc. In essence, these are indicators for the teaching effectiveness (Shulman, 1986, p. 5-6).

Shulman, through his theory, finds that many times education policy focuses on teachers' cognitive background, but almost never on how this knowledge will be "translated" into educational practice, in the student's knowledge and will be part of their teaching methods. Moreover, as Shulman notes "Content Knowledge" (CK) goes hand in hand with "Pedagogical Knowledge" (PK), by qualifying the "Pedagogical Content Knowledge" (PCK) model (Krauss et al., 2008, p. 717). On the basis of this model, we see overall the teaching and pedagogical methods of the teacher in the classroom. For example, we realize why a teacher chooses to teach a course or didactic unit with specific sources, methods and teaching techniques, how he/she teaches this section, what he/she emphasizes, what questions he/she asks and how he/she perceives the student potential of his/her classroom. Teaching therefore seems to be not only about the teaching subject, but also to the strategies chosen by the teacher to teach effectively (Shulman, 1986, p. 7-9).

2.1 The "Technological Pedagogical Content Knowledge" Model (TPACK)

The evolution of the above model gives us another important element in the modern teachers' professional development. In addition to subject matter knowledge, the acquisition of pedagogical techniques in teaching and learning, the familiarity with digital applications is now added through so-called Educational Technology (see Figure 1). A third "cycle" therefore comes to further enhance the relevant research interest and to add to the relevant discussion questions about interaction technology and how it can be exploited by teachers. Modern technology is the last -so far- "cycle" in the "Technological Pedagogical Content Knowledge" model (Mishra & Koehler, 2006).

This model begins with the deficient approach in the field of teacher education, which focuses, unilaterally, either on the cognitive background of teachers or on the pedagogical approach that teachers exploit in their teaching. The addition of technology to this model (Technological Knowledge/TK) seems to be "necessary evil" or better "inevitable", as in modern times technology has clearly penetrated teachers' educational practices and changed the nature of the classroom or, as Mishra and Koehler mark, offers all the possibilities for doing so (Mishra & Koehler, 2006, p. 1023). Modern technology is therefore another important element that maybe strengthens the teachers' role.

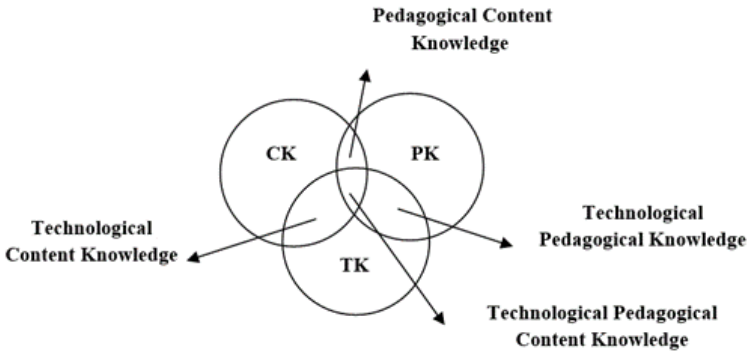


Figure 1. TPACK Model
Mishra & Koehler, 2006, p. 1025

Based on this dynamic model, effective teaching is related to the knowledge of both the content knowledge, the pedagogical techniques used by the teachers and the technologies they exploit in their classrooms. In addition, the modern teachers must lovingly link the subject matter content with the appropriate pedagogical and teaching strategies, while effectively utilizing Information and Communication Technologies (ICT) to enhance teaching.

2.2 Surveys about the TPACK Model

Numerous research studies reflect upon the "Technological Pedagogical Content Knowledge" model in teachers and pre-service teachers of all specialties, internationally (Harris et al., 2017; Hofer & Harris, 2012). Most of these research studies are initiated by the assumption that in modern educational reality effective teaching is the result of both adequate subject matter knowledge and pedagogical methods and the exploitation of modern technology in the classroom. It is also noted that research in this field is of high importance, because the extent to which a teacher can use educational technology is perceived. This model with the well-known tripartite distribution detects not only the knowledge that the teachers have in their subject matter, in pedagogical issues and technology, but also their handling in the educational process.

It is therefore possible for the teachers to have many elements from the third "cycle" (Technological Knowledge/TK), but to be lagging behind in the method of teaching, so that they can link the subject matter knowledge to the students' needs and to make their course more attractive at the same time. Of course, the above research provides us with data on the teachers' confidence about technology (Graham et al., 2009, p. 76).

It is of particular interest that several relevant surveys have the pre-service elementary and secondary teachers as participants. Important element because we can understand what is the profile of modern teacher, as (pre)shaped by his/her initial studies (Chai et al., 2011). The proper preparation of the pre-service teacher has for several years been removed from the logic of unilateral familiarity with the teaching subject. The modern approach to teacher education focuses on their appropriate familiarity with pedagogical methods, teaching techniques and strategies and with digital programs and applications (Hofer & Grandgenett, 2012, p. 84). Of course, with the appropriate placement in social context and the requirements of the educational system.

The core of these research is found in qualified an expert teachers, in order to seek to evaluate their knowledge on the basis of the well-known triptych (content knowledge, knowledge of pedagogical techniques and technology knowledge). Quantitative surveys shall be carried out with closed-type-classified methodological tools, as well as rubric assessment, characterized by reliability and validity (Hoffer et al., 2011). Qualitative research on this model focuses on interviews and observation of teaching.

Several research data on the "TPACK" model is collected as part of undergraduate students' courses or as part of tertiary and adult education programs for pre-service and in-service teachers. Some of these surveys control teachers' knowledge, skills and attitudes towards the three "circles", before a program is carried out, during the program and at the end of such a program (Pierson, 2008).

In particular cases, the findings of these surveys seem to converge on the fact that a teacher should focus on "Technological Pedagogical Knowledge" (TPK) model (Figg & Jaipal, 2009). It is therefore apparent that a modern teacher is not judged to be effective only if he/she is aware of the subject matter knowledge "cycle". Clearly, that's a precondition, but not an end in itself. The programs, through which teachers were evaluated in these surveys, focus on knowledge of pedagogical methods and familiarity with educational technology and not just with technology (Niess et al., 2006).

3. The research

3.1 Purpose and research hypotheses

The purpose of this research is to illustrate the professional profile of 100 secondary in-service teachers who teach in public schools at Thessaloniki, based on the "Technological Pedagogical Content Knowledge" model, through the self-assessment of their knowledge, skills and attitudes. In particular, the research recorded the participants' perspectives of their familiarity with their teaching subject, issues of pedagogical approaches and with educational technology.

The hypotheses of quantitative research are as follows:

- The in-service teachers will be familiar with their teaching subject, in particular those with more than 10 years of teaching experience.
- The sample will present a satisfactory level of knowledge on issues of pedagogical techniques and teaching strategies.
- To a lesser extent they will have an adequate level of familiarity with technology and, above all, male secondary teachers.
- At a low rate they will claim to involve their students in situated learning by exploiting Information and Communication Technologies (ICT).

3.2 Method, participants and ethics

For the purposes of this research was constructed a structured questionnaire as a basic methodological tool (a) with the personal information of in-service teachers (gender, age, studies), (b) with 42 closed 5-degree Likert questions, on the teaching subject, for their pedagogical competence and on familiarity with ICT, and (c) by assessing their knowledge in ICT programs and applications (based on the Koh and Chai questionnaire).

The participants, with the technique of convenience sampling (snowball sampling) (Creswell, 2008) are philologists, who teach in High Schools at Thessaloniki. Of the 230 teachers who received the online questionnaire, 100 valid, completed questionnaires were collected and coded with the SPSS statistical package. This survey presents both data through descriptive statistics and from the correlations of variables. All the ethical principles in the research were also complied with.

4. Statistical Analyses and Results

4.1 Demographic characteristics

The sample of the research consists of 32 male and 68 female in-service teachers who teach at Secondary Schools in Thessaloniki. Most are in the 46 to 55 age group (56.0%). A percentage of 20.0% are teachers 36 to 45 years old. Consequently, as most teachers are in a fairly large age category, their years of experience in education are from 11 and above (overall: 87.0%). Of these, 80.0% do not have a master's degree and only one (1%) has a doctorate degree.

4.2 Content Knowledge (CK)

"What is their professional profile based on self-assessment of knowledge, pedagogical techniques and their competence in digital tools and means?". Initially, with regard to the first "cycle"; "Content Knowledge" (see Table 1), it is found that a fairly high percentage is concentrated in the choice of "very good" and "extremely good" in terms of its teaching competence. Also, overall, a figure of 88.0% consider themselves to be professional and can teach as "experts". Also high are the percentages of in-service secondary teachers, who declare that they alone can and teach effectively and deepen their subject matter knowledge ("extremely good": 45.0%), while having a lot of confidence ("extremely good": 53.0%). In all of the above, through statistical analyses, it is clear that male philologists feel more professional, more knowledgeable than female philologists and have more confidence in their teaching (p. value < 0.05).

Table 1. Content Knowledge

Content Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I have sufficient content knowledge about my teaching subject	0.0%	1.0%	11.0%	41.0%	46.0%
I can think about the content knowledge of my teaching subject like a subject matter expert	1.0%	1.0%	9.0%	38.0%	50.0%
I am able to gain deeper understanding about the content knowledge of my teaching subject on my own	0.0%	2.0%	9.0%	42.0%	45.0%
I am confident to teach the content knowledge for my teaching subject	1.0%	2.0%	4.0%	37.0%	53.0%

4.3 Pedagogical Knowledge (PK)

The "cycle" of "Pedagogical Knowledge" (see Table 2) for one more time finds the philologists of this research to evaluate themselves very high. Therefore, they claim that cumulatively (at large scales) they are at 98.0%, that through their activities in the classroom (non-digital) they contribute or attempt to contribute to the strengthening of critical thinking skills for their students. They also claim that guide students so that they can be reflected on learning (80.0%), fostering autonomous learning skills (87.0%) and skills of active learning (72.0%).

Through the correlations of variables it becomes apparent that years of experience in education and the teachers' gender play a significant role. More specifically, teachers over 11 years of teaching experience seem to be more attempting to integrate techniques that contribute to the reflection of students in the educational process (x^2 (1) =7,751, p. value: 0.05). Moreover, male teachers seem to make more use, based on what they refer, of learning by doing method (x^2 (4) =13,090, p. value: 0.011).

Table 2. Pedagogical Knowledge

Pedagogical Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I am able to stretch my students' thinking by creating challenging tasks for them	1.0%	1.0%	17.0%	45.0%	36.0%
I am able to guide my students to adopt appropriate learning strategies	1.0%	1.0%	7.0%	36.0%	54.0%
I am able to help my students to monitor their own learning	1.0%	1.0%	10.0%	49.0%	38.0%
I am able to help my students to reflect on their learning strategies	1.0%	2.0%	16.0%	43.0%	37.0%
I am able to plan group activities for my students	0.0%	4.0%	20.0%	34.0%	41.0%
I am able to guide my students to discuss effectively during group work	0.0%	6.0%	21.0%	46.0%	26.0%

4.4 Pedagogical Content Knowledge (PCK)

If we attempt to discuss the results of the research on the so-called "Pedagogical Content Knowledge" (PCK) model, as shown in Table 3, several of the participants are interested in the cognitive deficits of their students and focus on them without using technology (44.0%). It is also noted that teachers use the appropriate teaching methods, by various means, without digital tools (35.0%), with the aim of a deeper understanding of the teaching subject by students (34.0%), especially for those who hold a master's degree (x^2 (5)=16,364, p. value: 0.006). And here the answers vary by gender, with male secondary teachers more involved in the above (x^2 (3) =10,900, p. value: 0.012). However, a fairly high percentage of the sample (76.0%) agrees that familiarity with technology is not a priority and is no more important than familiarity with the teaching subject and with issues of a pedagogical optics.

Table 3. Pedagogical Content Knowledge

Pedagogical Content Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
Without using technology, I can address the common learning difficulties and misconceptions my students have for my teaching subject	0.0%	0.0%	19.0%	36.0%	44.0%
Without using technology, I know how to select effective teaching approaches to guide student thinking and learning of the subject matter for my teaching subject	2.0%	12.0%	17.0%	33.0%	35.0%
Without using technology, I can help my students to understand the content knowledge of my teaching subject through various ways	2.0%	9.0%	18.0%	35.0%	34.0%

4.5 Technological Knowledge (TK)

Concerning the "cycle' of "Technological Knowledge" (TK), it is understood, through the teachers' self-assessments, that they possess the basic, at least, knowledge of computer utilization, but with the percentages divided between "moderately", "very good" and "extremely good", without being particularly high. Even lower are the rates, when teachers are asked to evaluate their knowledge of specialized educational software packages (28.0%). In particular, it should be noted that male in-service teachers claim to make more use of technology and educational software in their teaching (x^2 (4) =11,168, p. value: 0.025). Once again, male teachers seem to be familiar with basics and specialized digital programs (p. value < 0.50), and especially teachers with a master's degree (x^2 (5) =11,546, p.value: 0.042).

Table 4. Technological Knowledge

Technological Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I have the technical skills to use computers effectively	0.0%	4.0%	17.0%	35.0%	42.0%
I am able to use the basic ICT programs	1.0%	3.0%	21.0%	35.0%	38.0%
I am able to use specific ICT tools (e.g. blogs, wikis, google docs, google sites, timelines, concept maps)	1.0%	7.0%	25.0%	38.0%	28.0%

4.6 Technological Pedagogical Knowledge (TPK) & Technological Content Knowledge (TCK)

With regard to "Technological Pedagogical Knowledge" (TPK) there is a weakness of teachers, with rates significantly lower as we move to the high scales (see Table 5). In other words, it is noted that despite their adequate level of familiarity with ICT, most of the teachers in this sample do not know how to help their students to search online for their teaching subject (9.0%), to use digital means appropriately for teaching purposes (14.0%) and encourage students to cooperate with the assistance of modern and interactive technology (10.0%). Statistically a significant difference is observed between years of experience in education and encouraging students to exploit ICT by teachers. In particular, it is noted that teachers with fewer years of teaching experience are more encouraged to help their student using technology (x^2 (15) =26,147, p. value: 0.037).

Table 5. Technological Pedagogical Knowledge

Technological Pedagogical Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I am able to facilitate my students to use technology to find more information on their own	6.0%	11.0%	33.0%	40.0%	9.0%
I encourage my students to use technology for my teaching subject	7.0%	13.0%	37.0%	28.0%	14.0%
I am able to facilitate my students to collaborate with each other using technology	4.0%	10.0%	30.0%	44.0%	10.0%

The percentages are notably more enhanced in terms of "Technological Content Knowledge" (TCK) model (see Table 6). In particular, we see that the teachers in this research make the most of ICT in their teaching, as well as social media, collaborative learning environments and special purpose educational software.

Table 6. Technological Content Knowledge

Technological Content Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I can use appropriate technologies to present the content of my teaching subject	0.0%	6.0%	29.0%	37.0%	26.0%
I know about the technologies that I have to use for the research of content of my teaching subject	1.0%	3.0%	11.0%	50.0%	34.0%
I can use social media for my teaching subject	5.0%	19.0%	18.0%	27.0%	30.0%
I can use collaborative tools for my teaching subject	3.0%	8.0%	26.0%	36.0%	26.0%
I can use the software that are created specifically for my teaching subject	7.0%	17.0%	26.0%	26.0%	22.0%

It is therefore found that technology is more exploited in the context of the teaching and not so much pedagogical approach to learning, and especially by male teachers (x^2 (5) =12,262, p. value: 0.031). Moreover, mainly in-service secondary teachers with a master's degree seem to know better how to search for effective digital means for their teaching subject, than teachers with basic qualifications (x^2 (5) =12,191, p. value: 0.032).

4.7 Technological Pedagogical Content Knowledge (TPACK)

About a third of the teachers, especially qualified teachers (with a master's degree and doctorate degree, p. value < 0.05) of this research claims that can use technology to create activities for teaching subject, which will contribute to the formulation of cognitive shapes and different visual approach to learning (27.0%).

Table 7. Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge	Not at all	Slightly	Moderately	Very good	Extremely good
I can structure activities to help students to construct different representations of the content knowledge using appropriate ICT tools (e.g. webspiration, mind maps, wikis)	1.0%	6.0%	27.0%	38.0%	27.0%
I can formulate in-depth discussion topics about the content knowledge and facilitate students' online collaboration with appropriate tools	2.0%	9.0%	31.0%	35.0%	22.0%
I can design lessons that appropriately integrate content, technology and pedagogy for student-centered learning	15.0%	23.0%	22.0%	22.0 %	17.0%

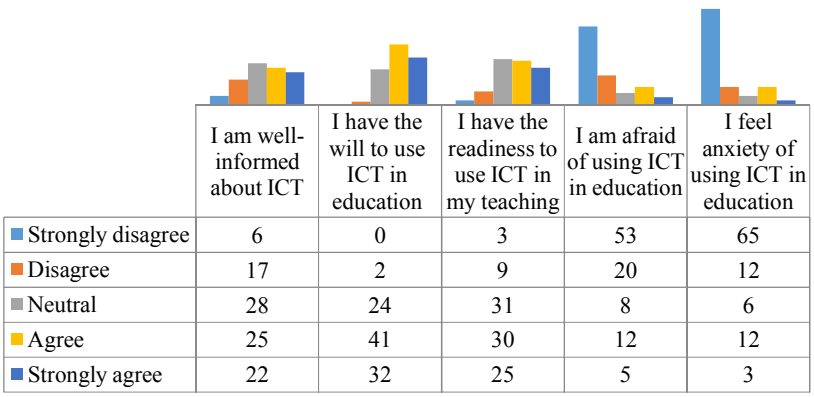
Even lower are the rates for teachers who can create the appropriate ICT environments, so that students can understand in depth an issue through collaboration and exploitation of digital tools (22.0%). Similarly, only 17 out of 100 secondary teachers create lesson plans, aiming at the multimodal and multilevel approach to an issue, with content knowledge, pedagogical techniques and appropriate technology. Finally, it is noted that teachers who are more confident about their teaching subject and, at the same time, have sufficient digital skills make more use of technology, involve students in learning more actively and design their teaching and pedagogical steps more effectively (p. value < 0.05).

4.8 Attitude towards ICT

With regard to the teachers' attitude towards ICT, it is understood that the most teachers do not feel anxiety when using technology in education. Of course, the analyses showed that female teachers are more likely to feel a lot of anxiety in such a situation (x^2 (5) =19,825, p. value: 0.001) or even be afraid to use ICT in their teaching (x^2 (5) =19,754, p. value: 0.001). Many teachers (41) are also willing to integrate technology into education and respectively a percentage of 30.0% feel fully prepared for it. Also, teachers with over 11 years of experience in education do not consider teaching focused exclusively on digital media (x^2 (6) =14,619, p. value: 0.023)

It is worth mentioning the fact that 24.0% of the sample is in favor of traditional methods and mainly concerns female teachers (x^2 (5) =18,065, p. value: 0.003), while respectively 40.0% of the sample, for male teachers, is in favor of modern teaching methods by exploiting technology. Also, 82 out of 100 teachers agree that it is more important to know their teaching subject rather than be familiar with technology; a view that is supported more by women than men teachers (x^2 (2) =12,361, p. value: 0.002). Furthermore, 71 teachers agree that "Pedagogical Knowledge" skills are more important than "Content Knowledge" skills, with men more strongly in favor of this view (x^2 (2) =6,809, p. value: 0.033).

Chart 1. Attitude towards ICT



	I am well-informed about ICT	I have the will to use ICT in education	I have the readiness to use ICT in my teaching	I am afraid of using ICT in education	I feel anxiety of using ICT in education
Strongly disagree	6	0	3	53	65
Disagree	17	2	9	20	12
Neutral	28	24	31	8	6
Agree	25	41	30	12	12
Strongly agree	22	32	25	5	3

5. Discussion

Teachers usually argue that they cannot achieve everything in their educational practice. They wonder whether it is enough only to acquire and update knowledge about their teaching subject. They are also concerned about the appropriate teaching and pedagogical methods to be used. In modern times, the fear of "elusive" is now created: *"Will I be able to learn what is new and can improve my teaching?"*. If we are caught up in this, with the fear of inadequacy and failure or get carried away of "glitz factor", we will not achieve enough. On the contrary, teachers as "critic consumers" must choose their own teaching strategies and how to strengthen their professional identity. In such a point of view, this research gives usable data on the profile of in-service teachers and the targeting they give either to the subject they teach, in their pedagogical approaches or in the exploitation of digital tools or in the combination of the above. In such a triptych, the correlations that arise are considered important and highly usable.

In particular, according to the first research hypothesis, the modern teachers of this research do feel that they are very good or excellent knowledgeable about their teaching subject (Content Knowledge/CK) and argue, to a fairly high degree, that they have those elements, which make them professionals in the field of teaching and education. They also claim that self-education and autonomous/independent learning can effectively improve and teach the modern students' generation. Their sense of self-confidence is very high, which seems to contribute to their positive image of their professional identity. This finding is similar to other research results (Karakaya & Avgin, 2016). The correlations show that the male philologists with over 11 years of teaching experience outline the profile of the qualified and highly effective teacher. Female teachers of this research are more cautious and less confident (Yuen & Ma, 2002).

The second research hypothesis is confirmed, as the participants in the research assess at a satisfactory up to very good knowledge level and pedagogical skills (Pedagogical Knowledge/PK) (Archambault & Barnett, 2010). In particular, they note that they actively involve students in group and active learning activities. Moreover, a very large percentage of the sample claims to guide students to think critically, reflect, learn autonomously, adopt appropriate learning strategies and cooperate effectively with other peers. Similarly, male teachers with over 15 years of experience seem to be more effective in the above, but without reference to technology. It is also understood that male teachers with a master's degree are more likely to involve students in pedagogical learning environments by linking them with their teaching subject flexibly and effectively (Pedagogical Content Knowledge/PCK). Characteristics in experienced and inspiring teachers with the necessary expertise (Berliner, 2004).

With regard to the third research hypothesis, teachers assess at a very high level the knowledge and skills of their digital literacy. They argue that they are very well aware of how the basic computer and ICT applications and programs are handled (Technological Knowledge/TK). This report is more suited to male teachers in this survey. Of course, this perspective directs us to the mechanistic use of technology by teachers who know how to use it, but do not know how to integrate it

creatively and functionally into their teaching (Koehler et al., 2013). As to linking technology with their teaching subject, there is a significant degree of fluency from male teachers with increased qualifications. Teachers, in other words, focus on the exploitation of technology for teaching purposes, seek sources for their subject and utilize educational software to their lessons.

The research also showed that indeed in-service secondary teachers, either at higher or lower rates, hold data from all three "cycles" of the TPACK model. In particular, we understand that despite their high cognitive background, their satisfactory pedagogical knowledge and the very good level of ICT knowledge and skills, when these elements need to be combined, the "bridge" is not accessible. In other words, despite the fact that teachers use their pedagogical knowledge and combine this with their teaching subject, there is an inability to link the subject matter knowledge with pedagogical methods and pedagogical ICT exploitation (Technological Pedagogical Content Knowledge/TPACK). It is noted, however, that teachers with little professional experience are more positive about technology and their connection to corresponding pedagogical techniques. Perhaps this is also due to the fact that the new teachers' generation socialized at a time when technology was ubiquitous or their initial education may have contributed to it.

Despite the fact that teachers with extensive experience in education are knowledgeable of their subject matter, educationally implicating students in learning, they are nevertheless unable to use technology in a pedagogical way. To a lesser extent, therefore, they seem to either integrate creative activities into their teaching, with the aim of helping students to shape different perspectives of a subject, utilizing the appropriate technological means or designing lesson plans with appropriate content, pedagogical view and using the appropriate technology every time (Liang et al., 2013). In the above, for a more complete picture of the teachers' professional identity, the feeling of self-confidence can be added to their subject matter, pedagogical and educational technology, as well as their experience, increased qualifications, but also their scientific assumptions about teaching (e.g. if they consider technology to be useful in education, if they are technophobes, etc.).

To conclude, by limiting the small and unrepresentative sample of this research, the modern teachers (especially males) with at least 11 years' experience in education and with advanced degrees, with a high sense of self-confidence in their subject matter, without fear of technology, with the adoption of the view that technology is necessary in modern teaching, but not panacea, teach more effectively, exploit modern teaching methods, implicating students pedagogically in the learning process. However, it appears that despite their satisfactory level of computer literacy they do not exploit technology with pedagogical targeting compared to the teachers who have less years of teaching experience.

Evidently, technology is not the only way out for effective teaching in modern school reality. It can be added, compulsively and rightly, as another "circle" in the qualifications that the modern teacher ought to possess, but we should be very careful, wary and sober to reflect on the knowledge and skills of a teacher. There is no doubt that the teacher cannot succeed in teaching without expert

knowledge of his/her subject matter. Now, subject matter knowledge also draws issues of pedagogical competence, which is why we cannot and are not allowed to turn a blind eye or to *"have the head in the sand"*. A secondary teacher must be trained, certified and pedagogically expert. In the issues of educational technology and the exploitation of digital means, many times, we fall into a hole we have dug. Let us dare to get out of the narrow view of ICT education and use technology creatively, pedagogically, holistically, interdisciplinary, situated, based on the experiences of our students, on the basis of a social framework. The modern teacher firstly and foremost must respond: *"Where do I want to go?", "What I want to teach", "How can I make it work?"*. I firmly believe that teachers as reflective practitioners can teach effectively, giving focus each time on the appropriate "circle", taking the needs of their students into consideration.

References

Archambault, L. M., & Barnett, J. H. (2010). Revisiting Technological Pedagogical Content Knowledge: Exploring the TPACK framework. *Computers & Education*, 55, 1656-1662.

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education*, 20(2), 107-128.

Berliner, D. C. (2004). Expert teachers: Their characteristics, development and accomplishments. *Bulletin of Science, Technology and Society*, 24(3), 200-212.

Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, 57(1), 1184-1193.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education, Inc.

Figg, C., & Jaipal, K. (2009). Unpacking TPACK: TPK characteristics supporting successful implementation. In: I. Gibson, R. Weber, K. McFerrin, R. Carlsen, & D. A. Willis (eds.) (2009), *Proceedings of Society for Information Technology Teacher Education International Conference* AACE: Chesapeake, VA.

Graham, R. C., Burgoyne, N., Cantrell, P., Smith, L., Clair, L., & Harris, R. (2009). Measuring the TPACK confidence of in-service science teachers. *TechTrends*, 53(5), 70-79.

Harris, J. B., Phillips, M., Koehler, M. J., & Rosenberg, J. M. (2017). TPCK/TPACK research and development: Past, present, and future directions. *Australasian Journal of Educational Technology*, 33(3), i-viii. Available at: https://ajet.org.au/index.php/AJET/article/view/3907 (Retrieved: 3.9.2019).

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' Technological Pedagogical Content Knowledge and learning activity types. *Journal of Research on Technology in Education*, 41(4), 393-416.

Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of pre-service teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in E*ducation, 45(1), 83-106.

Hofer, M., & Harris, J. (2012). TPACK research with in-service teachers: Where's the TCK?. In: *Society for Information Technology and Teacher Education International Conference* (p. 4704-4709), Association for the Advancement of Computing in Education (AACE).

Hoffer, M., Grandgenett, N, Harris, J., & Swan, K. (2011). Testing a TPACK-based technology integration observation instrument. *Teacher Education Faculty Proceedings & Presentations*, Paper 19.

Ingersoll, R. M. (2005). The problem of underqualified teachers: A sociological perspective. *Sociology of Education*, 78(2), 175-178.

Karakaya, F., & Avgin, S. S. (2016). Investigation of teacher science discipline self-confidence about their Technological Pedagogical Content Knowledge (TPACK). *European Journal of Education Studies*, 2(9). Available at: https://www.oapub.org/edu/ (Retrieved: 4.8.2019).

Koehler, M., Mishra, P., Akcaoglu, M., & Rosenberg, J. (2013). *The Technological Pedagogical Content Knowledge framework for teachers and teacher educators*. Canada: CEMCA.

Koh, J. H., & Chai, C. S. (2016). Seven design frames that teachers use when considering Technological Pedagogical Content Knowledge (TPACK). *Computers & Education*, 102, 222-232.

Krauss, F, Brunner, M., Kunter, M., Baumert, J., Blum, W., Neubrand, M., & Jordan, A. (2008). Pedagogical Content Knowledge and Content Knowledge of secondary mathematics teachers. *Journal of Educational Psychology*, 100(3), 716-725.

Liang, J. C., Chai, C. S., Koh, J. H. L., Yang, C. J., & Tsai, C. C. (2013). Surveying in-service preschool teachers' Technological Pedagogical Content Knowledge. *Australasian Journal of Educational Technology*, 29(4), 581-594.

Lumpkin, A., Claxton, H., & Wilson, A. (2016). Key characteristics of teacher leaders in schools. *Administrative Issues Journal: Connecting Education, Practice, and Research*, 4(2), 59-67.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H. K. (2019). *Designing effective instruction*. Wiley: U.S.A.

Niess, M. L., Lee, K., Sadri, P., & Suharwoto, G. (2006). *Guiding in-service mathematics teachers in developing TPCK*. American Education Research Association Annual (AERA) Conference, San Francisco, CA.

Pierson, M. (2008). Teacher candidates reflect together on their own development of TPCK: Edited teaching videos as data for inquiry. In: K. McFerrin, et al. (eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference.* AACE: Chesapeake, VA.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Yuen, A., & Ma, W. (2002). Gender differences in teacher computer acceptance. *Journal of Technology and Teacher Education*, 10(3), 365-382.