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Smart Board and Academic Achievement in Terms of the Process of Integrating Technology into Instruction: A Study on the McA

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Abstract

The aim of this study was to determine the effect of the use of smart boards (SBs) on academic achievement in accordance with a multi-complementary approach (McA). The study was conducted in three stages: the first stage included the examination of meta-analytic and thematic reviews based on document review to obtain pre-complementary data and identify gaps with this data; the second one considered the process of obtaining post-complementary data with a view to eliminate the identified gaps; the third one implied the integration of the results in two stages and the presentation of recommendations to obtain complementary information. With these aims, meta-analytic, thematic and experimental analyses were carried out. The three-stage process including both qualitative and quantitative results contributed to the validity and reliability of the current study.

Key words: *experimental application; meta-analytic and thematic analyses; multi-complementary approach.*

Introduction

In the 21st century with technology showing rapid development, it has become compulsory for individuals to keep up with this rapidly changing situation. For this reason, the need to equip countries' education systems with the latest technological developments has become evident. In Turkey, a big step has been taken within the project 'the Movement for Enhancing Opportunities and Improving Technology', which was started by the Ministry of Education (MOE) in 2002, and with smart boards (SBs) being included in the education process. In this context, with the aim

of enhancing students' active participation in lessons, in various kinds and grades of schools, classes have been based on the use of SBs (MOE, 2014). With regard to this, instead of teacher-centred instruction, there is a process in which students are at the centre, and interactive learning is in the foreground (Riska, 2010). At present, students' success is only possible through the application of technological devices, e.g. computers, SBs and tablet PCs, as partly required in the modern era, in a class environment which uses them as a key element of teaching methods (Buff, 2012). In the existing study, the aim is to examine the effect of SBs' use level in the learning environment on academic success.

The idea that SBs increase success has been accepted by most educators, who believe that their use creates a rich learning environment in visual and auditory terms (Beeland, 2002). This encourages lesson attendance by increasing motivation and expanding the spans of concentration (Kennewell & Beauchamp, 2007), consequently improving the quality of education (Thompson & Flecknoe, 2003), and also showing that SBs are flexible and versatile. Moreover, they have been adopted as a device which supports learning in many ways, such as more effective multimedia presentation, greater action in productivity, support to the development of lesson sources and planning, and possible interaction in lessons. In the national and international body of literature, many studies about the use of SBs have been published (Ateş, 2010; Gursul & Tozmaz, 2010; Hennessy, Deaney, Ruthven, & Winterbottom, 2007). In these studies, carried out in different disciplines and dimensions, as well as considering the benefits provided by SBs, the problems that have been encountered during their use have been mentioned. On this point, Yıldız and Tüfekçi (2012) emphasize that, as a part of the education process, SBs have been one of the most effective and the most attractive devices, so they should be used by both teachers and students. Various studies have stressed the values of SBs, especially in terms of increasing academic success, providing savings on time, raising motivation and drawing attention (Burke, 2010; Çoklar & Tercan, 2014; Digregorio & Sobel-Lojeski, 2010; Lutz 2010; Warnock, Boykin, & Tung, 2011). Such results indicate that using SBs as a part of the process of teaching has an important contribution to make within the context of the teacher, the student and learning outcomes.

Moreover, when some of the studies regarding this subject are examined in detail, it can be seen that the use of SBs in different grades and lessons has led to different results. In a study, carried out by Ekici (2008), the effect of SBs on success in Mathematics has been compared with that based on traditional methods. The obtained results have shown that SBs affect success in a positive way and lead to permanent learning. On the other hand, in a study, conducted by Tataroğlu (2009), it has been determined that the use of SBs does not have any effect on students' academic success and self-efficiency level in teaching Mathematics. In this sense, even if it has been expressed by educators that SBs have a positive effect on success, attitude, motivation and many other factors, as the related results are not quite clear, it has been necessary to undertake additional

research at this point. Moreover, when it is taken into consideration that technological developments directly influence education applications, it has been clear that the effect of these technological opportunities on teaching activities should be determined.

The Aim and Significance of the Study

The aim of this study was to determine the effect of using SBs on academic achievement related to the process of integrating technology into instruction. The expanded use of SBs across classes is among the basic targets of the Turkish project 'The Movement for Enhancing Opportunities and Improving Technology'. Therefore, determining the efficiency of state investments through considering teachers and students' opinions was the reason for conducting the current study. The data are considered significant as they reveal the level of efficiency in terms of effort and labour, and demonstrate the requirements. Thus, the study is expected to contribute to both literature and practical applications with regard to the process of integrating technology into instruction. The most striking point in the study is the way of collecting, analysing and interpreting data since a different method was studied, which is called the multi-complementary approach (McA). It has been found in the literature review that there is a great number of studies including the use of mixed method (Creswell & Plano Clark, 2007; Esteves & Pastor, 2004; Onwuegbuzie & Combs, 2011; Onwuegbuzie & Dickinson, 2008; Onwuegbuzie & Johnson, 2006), recognized as one of the three major approaches (quantitative research, qualitative research, and mixed-method research) (Johnson, Onwuegbuzie, & Turner, 2007) and defined as mixing or combining both qualitative and quantitative techniques and approaches in a single research (Johnson & Onwuegbuzie, 2004). It has been roughly estimated that the ever-increasing number of such studies will emerge in the future. However, the current McA method differs from the mixed method in some ways, as it can be seen from the details given in the method section.

The three-stage study is remarkable and, due to the McA use, there can be achieved general, reliable and valid results. Both qualitative and quantitative data analysis components are given big and equal importance in this approach; all data are incorporated to make the related topic more understandable. In the present study, involving the use of SBs as the key topic, the main aims included: examining meta-analytic and thematic reviews to achieve pre-complementary data, identifying gaps via pre-complementary data, conducting the second stage to obtain post-complementary data, combining the results obtained in the first two stages and presenting recommendations with regard to complementary information. Therefore, studies on the use of SBs in the national/international area were examined through meta-analysis and thematic analysis. In addition, an experimental and a thematic study, based on interviews, was carried out to complete and eliminate the gaps resulted from the documentary analysis. In the third stage, meta-analytic and thematic results were compared with experimental and thematic results. This three-stage process,

including qualitative and quantitative results, contributed to the validity and reliability of the present study. Thus, the following sub-problems, based on the main aim of this McA-supported study, were specified:

1. In order to obtain pre-complementary data in the first study stage the following research questions were proposed:
   a. What is the effect size of SBs on academic achievement in the context of *meta-analytic review based on documentary analysis*? (Table 1)
   b. What is the effect of using SBs on academic achievement in the context of *meta-analytic review based on thematic analysis*? (Figures 3, 4, 5)
2. In order to obtain post-complementary data in the second study stage the research questions were:
   a. Is there a significant difference between the post-test scores of the experimental and control group, related to the use of SBs in Mathematics lessons? (Table 2)
   b. What is the effect of using SBs on academic success in terms of students' views? (Figures 6, 7)
3. In order to obtain complementary data in the third study stage the following research question was proposed:
   a. Do pre- and post-complementary data, obtained in the first and second stage, complement each other, and is their synthesis integrative?

Method

This study was carried out through applying a new approach, known as the McA, which can be defined as an approach based on using various analysis programs (SPSS, MetaWin, CMA, Nvivo, Maxqda, etc.) and on combining both qualitative and quantitative results within the framework of a holistic approach in order to ensure comprehensive, valid and reliable results (Batdı, 2016). So, the study was conducted in three stages. In the first stage, studies on SBs were searched for with the use of methods, such as documentary analysis/review/compilation (meta-analytic and thematic analysis), to find certain gaps in the given studies. The first McA stage was based on constructivism of which the pioneers were Piaget, Bruner, Vygotsky, Dewey, Gestalt and Glasersfeld. Pre-complementary information is used here in the McA, instead of former information in constructivism. The main aim is, therefore, to add new information to the former one in learning. In other words, while searching for a topic, it is necessary to review all the existing studies regarding the related topics. In the reviews, the gaps with regard to the related topics can be identified, and the information collected at this stage is considered as pre-complementary information. In this study, we firstly tried to review all the studies on the use of SBs. They were found with the help of different search engines (ProQuest Dissertations and Theses (PQDT), the Higher Education Council National Thesis and Dissertation Center, Google Scholar, Ebscohost-Eric, Francis Online Journals and ScienceDirect) and referred to the national/international area between 2000 and 2015. Following the

review of literature on the use of SBs, 24 studies were included, especially those with pre-tests and post-tests, and descriptive data ($\bar{X}$, ss, n), which enabled us to calculate effect sizes and to compare them. The information about a particular study, such as author's name, publication year, field, was given in 'The Meta-analysis Data Collection Form' (Appendix-1). The studies were selected from a total of 640 theses and articles. The total sampling number of the experimental group in the selected studies (n=24) was 1036, and that of the control group was 986. When the total number of both groups is considered, it can be seen that 2022 participants' views were included in those studies, which means that the present study included a great number of participants, so the results of the study can be regarded as generalizable and comprehensive. The Comprehensive Meta-Analysis (CMA) statistical program and the MetaWin program were used for data analysis. It can be seen that the distribution of effect size is greater than the expected change, due to sampling error (Lipsey & Wilson, 2001). Thus, the Random Effects Model (REM) was used. The results were evaluated according to Cohen's (1992) classification. The inter-rater reliability was calculated with the formula [consensus / (consensus + dissensus) x 100] suggested by Miles and Huberman (1994), and the outcome was found to be 100%.

A thematic review, regarding the use of SBs, was also conducted with the aim of enriching the pre-complementary data in the first stage, and extending the scope of the study. Using various resources in the collection of data ensures variety, increases internal validity (Yıldırım & Şimşek, 2005), as well as reliability and persuasiveness of the study. For this purpose, 14 studies (theses and articles) were searched for in the national/international area and collected through a documentary review based on content analysis in which readers were presented with a clear content (Yıldırım & Şimşek, 2008). The analyses were made by using the Maxqda program. Articles were coded as "A", theses within ProQuest Dissertations and Theses were coded as "PQDT", other theses were coded as "T" and articles from ScienceDirect database were coded as "SD" in the text while giving direct quotations from the studies within the above-mentioned search engines in order to support the related codes. The study and page numbers of quotations were also added (e.g. PQDT1-94: 94th page of thesis within ProQuest Dissertations and Theses coded as 1). In terms of reliability in the data analysis process, the agreement values (Cohen Kappa) among data coders were calculated (McHugh, 2012; Viera & Garrett, 2005) and interpreted as .692-.777, meaning a "good level of agreement".

The process continued with the second McA stage, including post-complementary information after the review of literature and the collection of pre-complementary information about the use of SBs (Figure 1). In this stage, an experimental dimension was applied for completing the meta-analytic and thematic dimensions based on documentary analysis, and for eliminating the previously identified gaps. It was identified, in the first stage, that the greatest difficulties were experienced in Mathematics lessons, and that the number of studies conducted on Mathematics

was sufficient for performing the analysis. It was, therefore, decided to carry out the experimental dimension with regard to Mathematics lessons. On the other hand, it was thought that the number of studies related to other lessons was smaller, and this is a problem when it comes to achieving the intended integrity because of insufficient data.

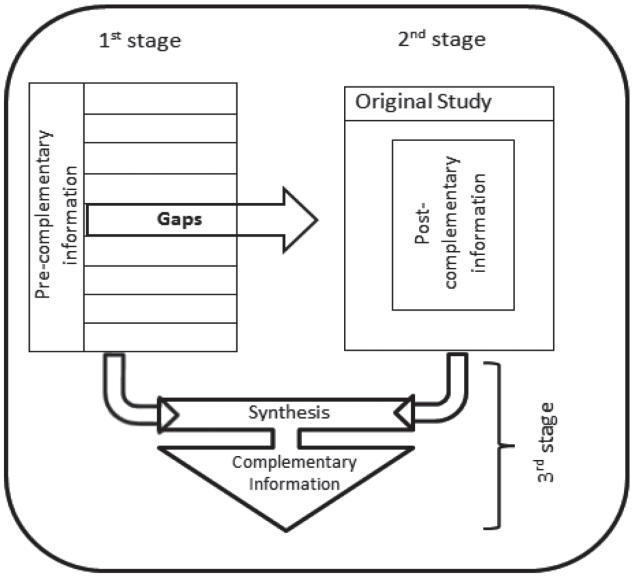

Figure 1. Complementary approach model

Through the use of a pre-test and post-test with the control group in the experimental part, the study incorporated a working group of 135 ninth graders of an Anatolian high school in Elazığ during 2014/2015 academic year. The students' neutral assignment was made through cluster analysis in which there were considered their final scores in Mathematics, Physics, Chemistry and Biology in the first term (Appendix 2). When the table in Appendix 2 is examined, it can be seen that there is no significant difference among the results regarding the first term scores in Mathematics, Physics, Chemistry and Biology. It can be stated, therefore, that the groups were created in a neutral way before the experimental process began. Additionally, the subject of 'Functions' was presented to the experimental group through the use of SBs during Mathematics lessons with ninth graders in the second term during 2014/2015 academic year. Following the pre-test and post-test, the related data were compared and presented in the discussion section. As a data collection tool, academic achievement tests were used, and data were analysed by using SPSS-17 and TAP analysis programs. The average difficulty of the 25-question achievement test was found to be .353, while the reliability coefficient of KR-20 was .789.

In the second stage, a *qualitative* dimension was added to the experimental dimension in order to contribute to the study scope and reliability, and to enrich data by collecting the students' opinions. An action research design was used for data assessment. The

working group included 12 students at three different levels of success - "$low_{(L)}$, $medium_{(M)}$ and $good_{(G)}$" - selected from students in the experimental part, involving the maximum variation sampling. It was possible, therefore, to define any case in detail, and to identify common aspects of students' views, which showed their different characteristics (Patton, 2002). The working groups were presented with a semi-structured interview form, developed by the researcher in cooperation with experts. Students were coded as $8G_M$ (A ***M***ale student with a ***G***ood academic level numbered as ***8***) and quotations from their views were stated in the text. These contribute to the external validity and are referred to a transferability strategy in qualitative studies, whose aim is to reveal cases clearly and to make detailed descriptions (Yıldırım & Şimşek, 2008). Data obtained from the interview forms were analysed through the Maxqda 11 program; the agreement values among the raters ranged from .800 to .821, which indicates 'good/very good agreement'.

The final section of this McA study included a synthesis. The pre- and post-complementary information about the use of SBs were combined in this stage to provide a holistic view of the study as Mertens (2011) stated in her study that, in mixed-method studies, there should be an integration of methods, analyses or finding reports. Additionally, in the current case, to synthesise the results did not mean just to combine the pre- and post-complementary information. Sönmez (2008) has emphasised that any created integrity is not a synthesis. This is because synthesis requires features, such as innovation, originality, inventiveness and creativity. In the present study, using the literature review in order to obtain pre-complementary information about the intended topic, carrying out an original (an experimental) study and combining the results of these two processes were considered as a unique and creative trend. Otherwise, it is not very possible to reach the related complement although the main aim of a study is to reach the whole information. With regard to this point, Russell (1912) has stated that reaching the whole truth should be regarded as an accommodation in a long journey, and added that the last point arrived at is not the final, but a closer step, in terms of reaching the whole truth. Thus, the last step always remains one step out of reach as any research and any improvements and developments in science are a step ahead of the last point arrived at. So, the steps are helpful, but only for being closer to the complementary information in the last stage.

Results

This study included three stages in terms of the McA. The meta-analytic and thematic reviews, based on documentary analysis, were performed during the first stage, while the experimental and thematic applications took place during the second stage. The meta-analytic results with regard to the effects of using SBs on academic achievement, compared to traditional methods, are presented in Table 1. The distribution of general effect size of the studies on academic achievement was determined to be heterogeneous, according to REM ($Q = 25.790$, $df = 23$, $p>.05$). In

addition, finding that there was significance in the value of a Q-statistical homogenous test, and seeing that the effect size distribution was greater than the expected change, due to sampling error (Borenstein, Hedges, Higgins, & Rothstein, 2009; Lipsey & Wilson, 2001), made the researcher to conduct analyses according to REM. The effect size was calculated to be ES=0.619 - in the large effect size, according to Cohen's (1992) classification. Moreover, the z-value was found to be 4.955 when the statistical significance was calculated according to the z-test, but no statistical significance was seen according to p value (p=0.33).

Table 1

The distribution of homogeneous values, average effect sizes and confidence intervals for the studies included in the meta-analysis based on the effect models

Model Type	n	Z	p	Q	ES	FS_N	95% Confidence Interval	
							Lower Limit	Upper Limit
FEM	24	13.348	0.000	159.494	0.616	1425.2	0.526	0.707
REM	24	4.955	0.316	25.790	0.619		0.374	0.863

df =23

In meta-analytic studies, unpublished null studies are required to remove the statistical significance from meta-analysis findings. In other words, a fail-safe number (FS_N) is calculated to remove the publication bias in meta-analysis (Rosenthal, 1979) (Table 1). In the present study, the value of FS_N shows that 1425.2 studies on the effect of using SBs on academic achievement should be included in the analysis in order to have a null effect size. As this number is very great, it can be asserted that the publication bias in the present study has no effect on a positive effect size (Cheung & Slavin, 2011) and that analyses are highly reliable.

Findings Collected from the Participants' Views in Studies Based on Documentary Analysis

Studies on the use of SBs at the national and international levels were examined in order to obtain pre-complementary information by adding a thematic aspect to the meta-analysis. With this aim, the views of participants in the related studies were observed in detail. The qualitative findings were categorised into various themes/codes, which were turned into models and presented in the form of three sub-titles.

The first model, created in accordance with the participants' views on the use of SBs, comprised the themes entitled "the positive effects of using SBs on cognitive, affective and social domains". The codes, related to the cognitive domain, showed that the use of SBs "appeals to numerous types of intelligence, presents visual richness through videos and animations and enables the user to create successful products". One of the studies, coded as T3-73, included expressions that '*... SBs are really beneficial...they can address students who have different types of intelligence...*' which was referenced to the related codes above. In addition, some of the codes, related to the affective domain, were stated, as the use of SBs "increases confidence and motivates teachers and students".

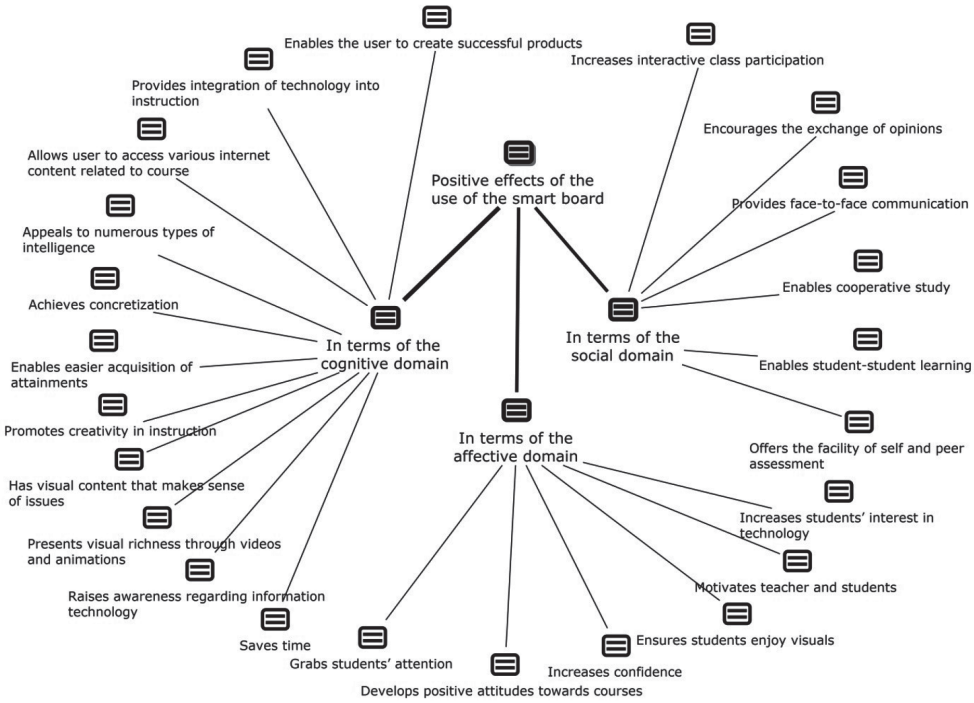

Figure 2. Positive effects of the use of SBs

Expressions that can be quoted for such codes were taken from the study, coded as PQDT12-94, and specified as "*Teachers' motivation increases when they use SBs and this increase also affects students' motivation.*" The last theme, including the social domain, comprised certain themes, such as that SBs "…enable cooperative study, increase interactive class participation and enable student-student learning". A quotation from the A18-502 coded study noted that "*My students use SBs technology with the aim to arrange and control their works interactively...*". This quotation is indicated as a reference for the codes above.

The codes created from the participants' views on the learning environment are presented with a model in Figure 3. In the context of the learning environment theme, codes such as "Establishing enjoyable learning environments and creating experimental media" were seen. These were based on the quotations from the studies coded as PQDT1-94 and T14-51, which noted, "*Students indicate active and willing participation in the course*" and "*it is a beneficial process due to its visuality. Watching experiments through videos facilitates understanding the topic.*" The codes "creating pedagogical awareness" and "encouraging learning to learn", taken from quotations from the PQDT8-75 coded study, were based on expressions, such as "*Interaction between the teacher and students should be very good...*" and "*It is essential to have learning proficiency and to learn by experiencing the teaching process*".

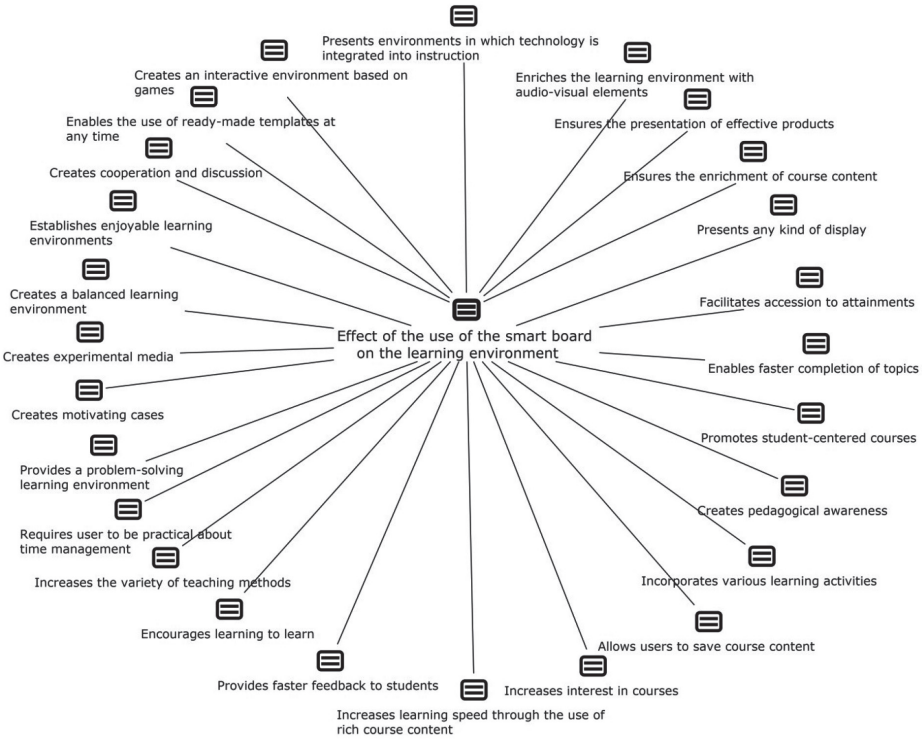

Figure 3. The effect of using SBs on the learning environment

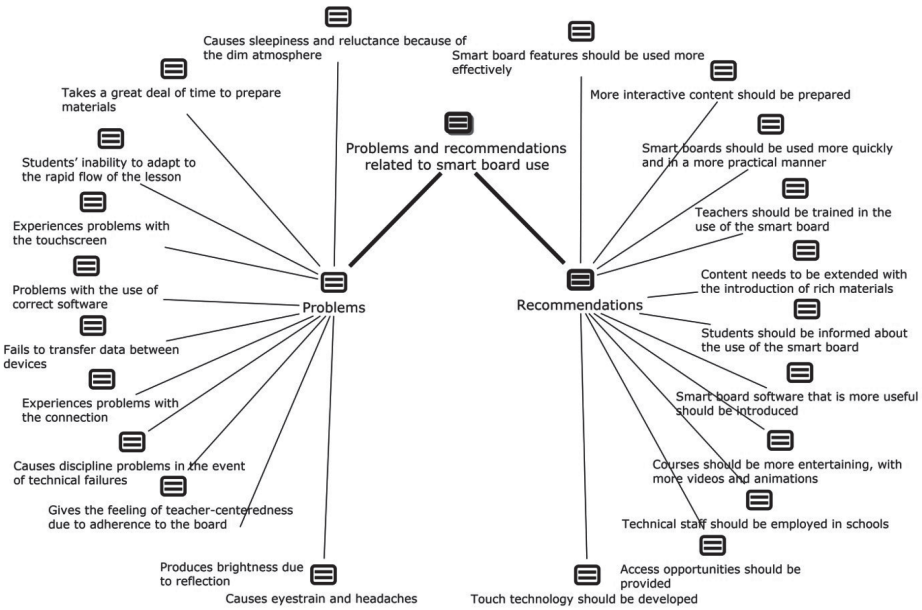

Figure 4. Problems and recommendations related to the use of SBs

Figure 4 includes the themes concerning the problems and recommendations that are related to using SBs. Certain codes, related to problems in the use of SBs, can be stated as "causing sleepiness and reluctance because of the dim atmosphere, causing discipline problems in the event of technical failure". The above-mentioned codes were taken from the study coded as T14-54 from the quotation of *"…the dark and sultry atmosphere of the class makes students reluctant."* Within the theme of recommendations codes, for instance, "content needs to be extended with the introduction of rich materials", "teachers should be trained in the use of SBs" and "more interactive content should be prepared" were cited from the studies. *"..With a more interactive content students' attention can be drawn..."* from T15-58 and "*…seminars can be given to teachers on the use of SBs and computer*" from T18-48 coded studies present the quotations which are the basics to the related codes noted above.

The Experimental Findings of the Study Regarding the Effect of Using SBs on Academic Achievement

The second stage of the McA-based study is presented herein, following the obtained pre-complementary information through meta-analytic and thematic dimensions in the first stage. Since the reason for preferring Mathematics lessons for the experimental dimension of the study has been given in the method section, the effect of using SBs on academic success in Mathematics lessons is presented below. An independent samples t-test was used for identifying the level of significance among the post-test achievement scores in the working group. Homogeneity of variances was tested first, and it can be seen that there was a distribution of homogeneity (F=1.787; p>.05).

Table 2

Comparing the post-test scores of cognitive academic achievement test

Groups	n	$\bar{X}$	ss	sd	Levene		t	p	ES
					F	p			
Experimental	33	9.00	3.24						
Control	33	7.48	2.36	64	1.787	.186	2.171	.034	0.530
Total	66								

p<0.05 ES:* Effect Size

A significant difference was found between the experimental and the control group with regard to their academic achievement scores. In addition, there was a significant difference between their mean scores at the rate of 1.52 in favour of the experimental group ($\bar{X}_{experimental}$=9.00; $\bar{X}_{control}$=7.48). When the values of t and p were considered to examine the significance of the level at which the two groups differed, the t value was calculated to be t=1.787, p<.05. The fact that this significance level was below p=.05 indicated a significant difference among the students' test scores. The given result reveals that the use of SBs in Mathematics lessons has a positive effect on students' academic achievement in comparison with the traditional approach. Moreover, the effect size of the experimental study was found to be ES=0.530, that is, at the medium

level according to Cohen's (1992) classification. It can be stated that the use of SBs in the learning environment affects success positively.

Thematic Results Obtained From the Participants' Views Following the Experimental Application

A thematic aspect, used for achieving post-complementary information, was added in this McA-based study. So, the students' views about the use of SBs in Mathematics lessons were collected to support and complete the experimental results. Through a content analysis, the data obtained from the students' views were analysed in the framework of certain codes and themes. The related themes were entitled "*Positive effects of SBs,* and *problems and recommendations related to the use of SBs*"; they are presented with the models below.

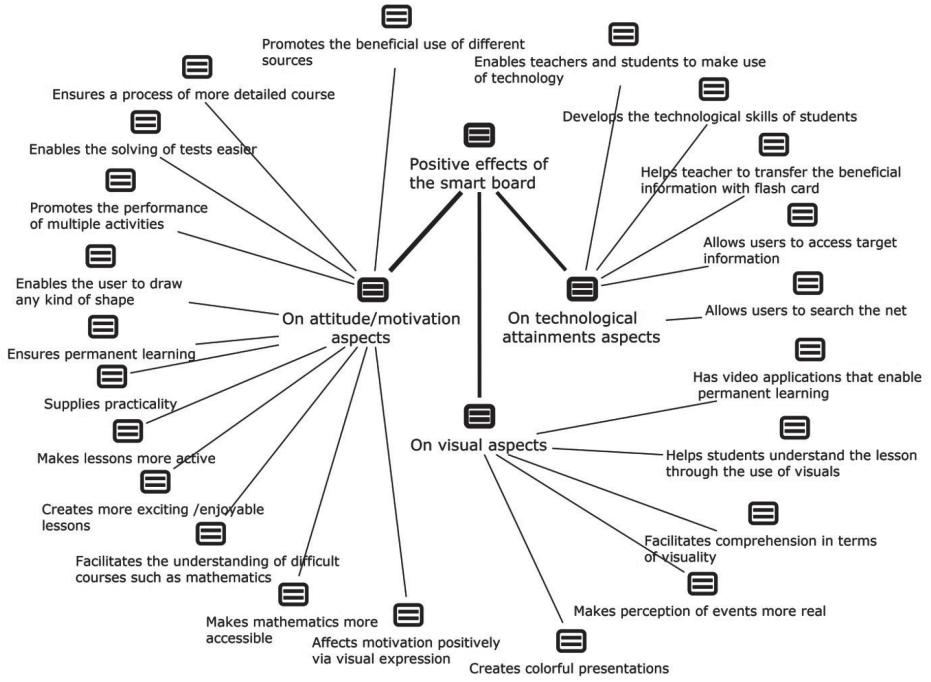

Figure 5. Positive effects of the use of SBs

In Figure 5, the positive effects using SBs in Mathematics lessons are mentioned. It is obvious that there are themes, such as the effect of SBs "on attitude/motivation, on visual and on technological attainment aspects". While the codes as the use of SBs "… makes mathematics more accessible. It ensures a more detailed course process, and it supplies practicality" were remarked under the theme of attitude/motivation, the codes expressed as "…SBs have video applications that enable permanent learning. It creates colourful presentations and makes the perception of events more realistic" were noted under the theme of visual aspects. Within the context of technological

attainment, the codes such as "…SBs develop the technological skills of students, allow users to search the net and enable teachers and students to make use of technology" were created. All the related themes and codes above were taken from the quotations as follows: "*...compared to previous lessons, the lessons supported with SBs are rich in terms of visuality and content, and I see that this property facilitates comprehension.*"($5G_F$); "*… SBs enable me to research a lot. I got the opportunity to search for the topics I wondered about because of the internet connection.*" ($8O_M$).

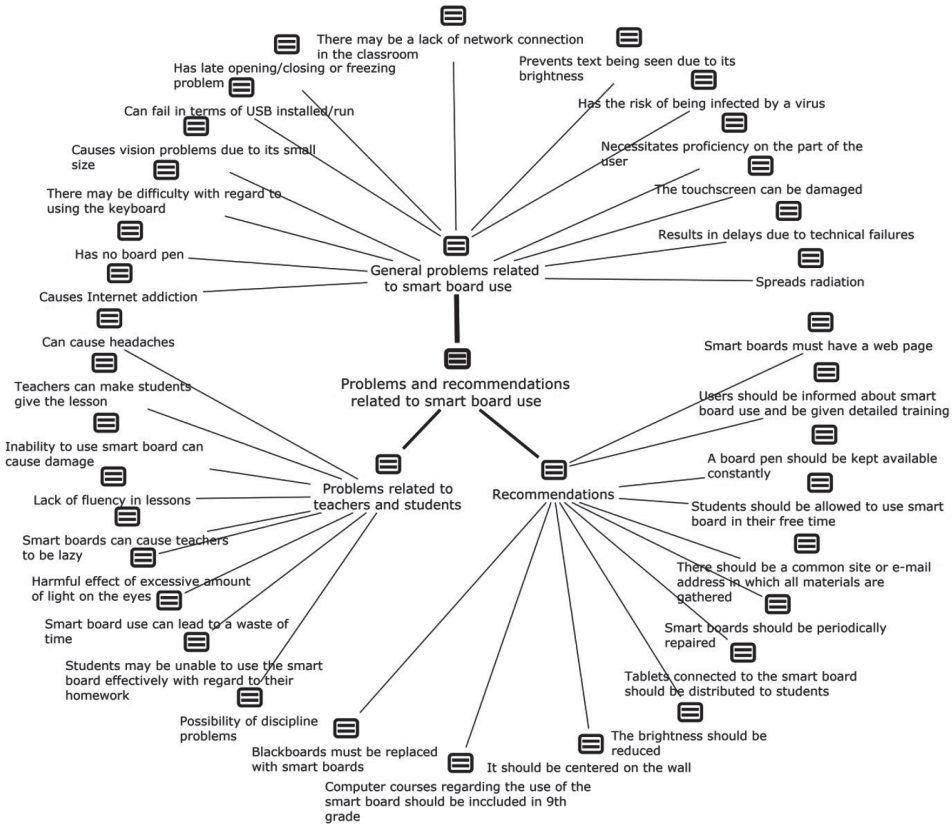

Figure 6. Problems and recommendations related to the use of SBs

It can be observed that the participants' views about using SBs in Figure 6 were given in terms of "general problems related to the use of SBs; problems related to teachers-students and recommendations". "SBs have late opening/closing or freezing problems, they can fail in terms of USB being installed/run, the touchscreen can be damaged, there may be a lack of network connections in the classroom" are the codes within the theme of general problems. Certain quotations from the students' views can be stated, such as "*We have experienced many technical problems, such as the impairment of electrical outlets, lack of network connections, freezing problems…*" ($7G_F$), and "*…the speed of connection, technical defects and continuous opening/closing of SBs may cause delays*

and a waste of time..." ($5M_M$). On the other hand, the codes including the problems, related to teachers-students, appeared as "Students may be unable to use SBs efficiently with regard to their homework, the inability to use SBs can cause damage, using SBs can lead to a waste of time and SBs can make teachers lazy." The related codes are based on the quotations from the expression of a student coded as $1G_M$ who pointed out that "*I do not think of the positive effect of using SBs on doing my homework.*" and of one coded as $3M_M$ who specified that "*More than half of the course time passes with the teacher's opening the document on the board or with calling someone to open the board as she/he doesn't know how to use the SB.*"

In Figure 6 some recommendations, related to the use of SBs, are also noted. These codes were stated as "Users should be informed about using SBs and given detailed training, SBs should be periodically repaired, and computer courses regarding the use of SBs should be included in 9th grade." The related codes are based on the quotations, as follows: While the student coded as $8L_M$ remarked that "*I was worried about using SBs at first, however, if a training process on using SBs is carried out, it can be very beneficial…*" the one coded as $11M_F$ recorded that "*There are always problems with SBs. It sometimes freezes or is infected by a virus. Thus, SBs must be repaired regularly.*"

Discussion and Conclusion

The effect of using SBs on academic achievement with regard to the process of integrating technology into instruction was examined in this study. The scope of the study was expanded with the use of McA, while meta-analytic, thematic and experimental aspects were added during the data collection procedure. With this purpose, in the first stage of the study, meta-analytic and thematic reviews were made to provide pre-complementary information about the use of SBs. In the meta-analytic results, the effect size of the academic achievement scores was recorded as 0.619 according to REM. This value was considered to be at the medium level, and was found to be positive and significant.

Besides, the thematic results indicated that SBs had positive effects in terms of cognitive, affective and social dimensions. At this point, a study by Amiri and Sharifi (2014) showed that the use of SBs positively affected writing skills, and students started to use a variety of adverbs and to write sentences more clearly, following the use of SBs. Moreover, using SBs also influences the learning environment by creating enjoyable and realistic media, and by giving the opportunity of learning to learn. Wood and Ashfield (2007) had similar conclusions in one of their studies in which they observed the delivery and pace of the learning session after the use of interactive white boards, that is, SBs. The whole-class teaching and learning process is facilitated through using SBs. On the other hand, certain problems related to the use of SBs and recommendations regarding these problems were recorded. Some of the negative results can be recognized in the dim classroom atmosphere, lack of content, problems with connections, and software. The above-mentioned negative points were

particularly observed in Mathematics lessons. Similar results have been observed in some studies from the related literature (Kevser & Çetinkaya, 2013; Schmid, 2008). A study, examining the efficiency of the project entitled 'the Movement for Enhancing Opportunities and Improving Technology', concluded that teachers do not have the necessary competence to use technological devices, and that they do not use technology relevant to the purpose (Özkan & Deniz, 2014). Thus, it can be suggested that teachers be given seminars or in-service education on the use of technology and/or SBs, in particular. Manny-Ikan and Dagan's (2011) result, which includes the necessary focus on the pedagogical training for teachers, was seen to be similar to the suggestions above. In the present study, such recommendations regarding the negative results of SBs are recognised as the need to inform students on the use of SBs. These recommendations are supported also by a study on the use of SBs in Mathematics lessons conducted by Çoklar and Tercan (2014). The meta-analytic and thematic results of the study, thus, indicated that both results were met at a common point which considers the positive effect of SBs on cognitive, affective and social dimensions.

After the first stage of the study, there was a medium but positive level of the effect size regarding the use of SBs on academic success, while the analyses of the studies included here showed that the effect size of the studies carried out, especially in teaching Mathematics, was calculated to be .404, meaning a small effect size. This small value made the researcher examine the related subject in detail. The use of SB in the above-mentioned lessons (Mathematics) may seem to be somewhat difficult; however, the study considered was estimated to eliminate the gaps identified with the pre-complementary data. For the second stage of the McA-based study, therefore, an experimental application to be conducted in teaching Mathematics was added. Besides, it was observed that there were many studies regarding the use of SBs in these lessons conducted at the secondary school level, but only a few have been conducted at the high school level; thus, a pretest-posttest controlled group experimental design was conducted within a 12th grade foreign language course in order to obtain post-integrated information (Appendix-1). In addition, when the studies included in the analysis were considered, it was recognized that most of them are national and international theses, rather than articles (Appendix-1). The current study, therefore, can contribute to the elimination of the gap, identified through analysing the pre-complementary data.

In the experiment, conducted with the aim of completing the pre-complementary results of the study based on documentary analysis, the subject of "Functions" in Mathematics lessons for 9th graders was taught with the use of SBs. Following this, a significant difference between the experimental group and the control group was in favour of the experimental group. A similar result in favour of the experimental group was found in a PhD thesis by Link (2012). The fact that the academic achievement of the experimental group was higher than that of the control group is similar to the current study results. So it can be stated that the use of SBs positively affects academic

achievement. The descriptive data from the experimental aspect of the study indicates that the effect size of the experimental study was calculated as being 0.530, which can be interpreted as the academic achievement of the experimental group in which the use of SBs was greater. Similar results can be seen in the studies conducted on the use of SBs in the related literature (Dhindsa & Shahrizal-Emran, 2011; Heard, 2009; Yıldız & Tüfekçi, 2012).

In the second stage of this McA study, a thematic aspect was added in order to support the study and enrich the data. As a result, it was remarked that interesting and audio-visual content could increase motivation, that SBs could develop positive attitudes, ensure more detailed courses, and give many opportunities to teachers and students. The similarity of the results between the first and the second stage implies that the study results are supportive and consistent with each other. The study by Phelps (2012) can be presented as a reference to the related results in which the use of SBs positively affected the students' participation with regard to the course. Additionally, Armstrong et al. (2005) claimed the importance of interactive whiteboards in promoting quality interactions and interactivity among students.

The final stage of the study in accordance with the McA was the synthesis. In other words, as part of this process, the pre-complementary information in the first and the post-complementary information in the second stage were combined and integrated. The meta-analytic results obtained in the first stage - including the positive effect size of SBs on academic achievement - and the thematic results - including the increase in motivation, contribution to the social aspect, achievement of attainments and determination of certain problems – were similar in terms of results in both stages. The results of the experimental aspect indicated that the effect of using SBs on academic achievement was greater than in traditional approaches. The related result was also similar as the meta-analytic and thematic results of the first stage. The thematic aspect of this McA study, with which the experimental application is to be supported and completed, consisted of the students' views. With these thematic results, it appears that the use of SBs includes interesting and audio-visual content which increases motivation, develops a positive attitude towards lessons, and has video applications that enable permanent learning. Bahadur and Oogarah (2013) also referred to the better engagement and enjoyment of students during the lessons where the white board was implemented and they confirmed teachers' agreement on white boards as effective tools. The above-mentioned results mean that the second stage of the study is complementary and integrative, indeed. Thus, the results obtained in each stage (pre- and post-complementary) of the study comprise four different analytical processes, which emphasize that SBs have positive effects on academic success in general. In addition, the results regarding the problems in the use of SBs are also similar in both stages. The similarity in findings signifies the consistency of the given results.

Certain considerable points in terms of the synthesis stage are to be stressed following the complementary results. The scientific meaning of the term synthesis

has been clarified in the method section as production, formation, suggestion and creation. The expressions based on suggestions were considered herein in the synthesis stage of the current study. The fact that there are not many studies regarding the use of SBs in teaching Mathematics and at the university level may be a suggestion for researchers to carry out new research on this issue. Moreover, studies concerning the use of SBs in the context of the project entitled 'The Movement for Enhancing Opportunities and Improving Technology' may be expanded. On the other hand, the results concerning the problems in the use of SBs can be seen in other studies (Phelps, 2012; Riska, 2010; Tataroğlu, 2009) and recommendations are, therefore, presented implying the importance of seminars and in-service training. At this point, Beauchamp's (2004) study on the use of interactive whiteboards underlines the need in preparing teachers for their new roles as white board users prior to the arrival of white boards. The current state of training programmes is, thus, seen to be insufficient, and studies regarding this issue may be recommended. The continuity of technological developments indicates that pre-service training programmes should be renewed periodically. Additionally, practical courses with regard to the use of SBs should be given to teacher candidates to provide them with sufficient knowledge and experience.

The thematic results of the study, collected from the students' views, emphasized the difficulty of content preparation with the use of SBs. Teachers can be trained in material preparation and development. Interactive materials for SBs may be prepared by a commission in the Ministry of Education as is the case with course books prepared by the Ministry, that are later sent to schools for practical use. Moreover, in the literature review, it was recognized that one of the advanced statistical techniques entitled cluster analysis, which was used for forming the experimental and control group, was not used in some studies. This recognition reminds us of the possible limitations of the studies considered due to the related gap. Consequently, cluster analysis is suggested for future research (Akdemir, 2009). In some studies (e.g. Buff, 2012), it was noticed that the difference in arithmetic means from post-test data were in favour of the control group. However, the difference was not statistically significant ($p=0.15>0.05$). The meta-analysis program considers this value as being negative, and indicates that the related result was in favour of the control group. Thus, the use of a meta-analysis program, together with programs such as SPSS, means the possibility of a precise and accurate evaluation of the McA. As a result, when the study is formalized in accordance with the McA, as seen in Figure 1, the following overview can be seen: *from the pre-complementary information*, it was observed that the use of SBs in teaching Mathematics seemed to be difficult, and there was a limited number of studies conducted at the high school level; *from the post-complementary information*, it appears that the use of SBs affects academic success positively, despite the problems in using SBs; and *from complementary information,* certain recommendations respecting the related problems were presented, with a view to increasing efficiency and productivity when it comes to using SBs.

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(Note: Studies marked with an asterisk (*) are included in the meta-analysis)

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Appendix

Appendix 1.

The Meta-analysis Data Collection Form

Effect Size	Author and Year	Effect size	Grade/ Class	N	Course/Field	Results/conclusions
	Akbaş & Pektaş, 2011	0.113	Üniv.	33	Science and technology	interactive white boards (IWB) ensured an interesting atmosphere, better visualization
	Sevindik, 2010	0.035	Health college	66	Nursing students	IWB provided face to face educational environments
	Buff, 2012	-0.340	Middle school	70	Science	no significant evidence of increased student achievement brought about by the IWB technology use
Negligible	Riska, 2010	0.000	6th grade	173	Mathematic	no significant growth was observed among gifted students who used IWB technology
	Emron & Dhindsa, 2010	0.056	Secondary School	88	Science	interactive whiteboard technology in learning environment was significantly higher
	Akdemir, 2009	-0.025	Üniv.	41	Geography	smart board teaching method improved the achievement of students in Physical Geography
	Uzun, 2013	0.035	6th grade	33	Mathematic	no significant difference between experimental and control groups
	Tataroğlu, 2009	0.328	10th grade	120	Mathematic	no significant difference between the academic achievements of the test and control group
Small	Phelps, 2012	0.321	Secondary School	76	Mathematic	strong and immediate teaching and learning benefits of using an interactive whiteboard
	Turan, 2014	0.202	Primary school	47	Mathematic	a successful student population in the experimental group which is higher than students in the control group is seen
Medium	Yorgancı & Terzioğlu, 2013	0.602	Üniv.	60	Mathematic	use of interactive whiteboard significantly enhanced students' achievement and attitude
	Yorgancı & Terzioğlu, 2013	0.602	Üniv.	60	Mathematic	use of interactive whiteboard significantly enhanced students' achievement and attitude

	Yorgancı & Terzioğlu, 2013	0.602	Üniv.	60	Mathematic	use of interactive whiteboard significantly enhanced students' achievement and attitude
	Sarı & Güven, 2013	0.566	Üniv.	106	Physics	the teaching materials used in experimental group significantly increased the students' motivation and academic achievement
	Ekici, 2008	0.609	6th grade	60	Mathematic	the results were quite remarkable and findings were very supportive of IWB use
Medium						
	Ermiş, 2012	0.436	6th grade	34	Science and Technology	the usage of IWB did not contribute to a significant difference
	Tercan, 2012	0.595	7th grade	65	Science and Technology	IWB increased the achievement levels of students in Science and Technology
	Tekin, 2013	0.669	10th grade	176	Physics	a significant difference was found in favour of experimental class students using IWB
	Link, 2013	0.570	7th and 8th grades	94	Mathematic	IWB-based instruction can help improve mathematics achievement
	Öztan, 2012	0.984	7th grade	43	Science and Technology	IWB could affect the success positively in science and technology classes
Large						
	Şen, 2013	0.935	4th grade	146	English	the use of IWB increased students English academic success more than the use of blackboard
	Watt, 2009	1.322	8th grade	72	Mathematic	a statistically significant pre- to posttest effect
Very large	Amiri & Sharifi, 2014	1.118	Secondary school	160	English	students used the adverbs more accurately in their writing when IWB was used in teaching
	Keser, 2012	2.175	6th grade	60	Social Sciences	IWB helps persistency of learning and increases the academic success of the students
Huge						
	Kaya, 2013	2.095	10th grade	31	Mathematic	IWB had significant effect on students' achievement
	Tiryaki, 2014	1.755	6th grade	168	Science and Technology	IWB increased the academic achievement in the Force and Motion

N: Total number of participants in the experimental and control groups

Appendix 2.

Independent Samples T-Test Analyses Regarding the Neutrality Criterion of Experimental and Control Groups

9th grade scores 1st term	Groups	N	X	SS	Levene		t	p
					F	p		
Mathematic	Experimental	33	73.58	13.50	1.564	.216	.258	.797
	Control	33	72.78	11.57				
Physics	Experimental	33	66.88	13.01	.213	.646	.879	.383
	Control	33	64.17	12.02				
Chemistry	Experimental	33	66.58	8.92	.496	.484	.909	.367
	Control	33	64.51	9.55				
Biology	Experimental	33	80.20	9.26	.067	..796	.894	.375
	Control	33	78.14	9.46				

*p>0.05 SD=64

Pametna ploča i školski uspjeh s obzirom na proces integracije tehnologije u nastavu: istraživanje o MkP

Sažetak

Cilj je ovog istraživanja utvrditi kakav je učinak primjene pametnih ploča (PP) na školski uspjeh, polazeći od multikomplementarnog pristupa (MkP). Istraživanje je provedeno u tri faze: prva je faza obuhvaćala metaanalizu i uvid u teme na temelju pregleda dokumenata da bi se dobili pretkomplementarni podatci i tako utvrdile postojeće praznine; u drugoj se fazi razmatrao proces dobivanja postkomplementarnih podataka da bi se eliminirale utvrđene praznina; treća je faza podrazumijevala integraciju rezultata iz prethodnih dviju faza i davanje preporuka za dobivanje komplementarnih podataka. S tim su ciljevima provedene metaanaliza i analiza tema, odnosno proveden je eksperimentalni dio istraživanja. Spomenuti je proces proveden u trima fazama, a obuhvaćao je rezultate kvalitativne i kvantitativne obrade podataka kao doprinos valjanosti i pouzdanosti istraživanja.

Ključne riječi: *eksperimentalni pristup; metaanaliza i tematska analiza; multikomplementarni pristup.*

Uvod

Obveza svakog pojedinca u XXI. stoljeću, kada se tehnologija intenzivno razvija, jest pratiti tako brzu promjenu situacije. Stoga je u obrazovnim sustavima raznih zemalja očigledna potreba za najnovijim tehnološkim dostignućima. U Turskoj je učinjen velik korak u sklopu projekta pod nazivom Pokret za poboljšanje mogućnosti i unapređenje tehnologije, što ga je započelo Ministarstvo obrazovanja (MO) 2002. godine tako što je uvelo pametne ploče (PP) u nastavu. U takvom se kontekstu u raznim školama i razredima planiraju nastavni sati s pomoću PP s ciljem aktivnijeg sudjelovanja učenika (MO, 2014). Na taj način učenici, umjesto nastavnika, imaju središnju ulogu u nastavnom procesu, a interaktivno je učenje u prvom planu (Riska, 2010). Danas, imajući u vidu suvremene potrebe, učenici mogu postići uspjeh jedino ako se u učionici kao ključni nastavni element koriste tehnološki uređaji, kao što su računala, pametne ploče i tableti (Buff, 2012). U ovom je istraživanju cilj utvrditi kakav učinak ima primjena pametnih ploča u nastavnom okruženju na školski uspjeh učenika.

Mnogi su pedagozi (Beeland, 2002) prihvatili ideju prema kojoj pametne ploče čine uspjeh boljim jer vizualno i auditivno obogaćuju nastavnu sredinu, a ujedno potiču dolazak učenika na nastavu jer im podižu razinu motivacije i produžuju vrijeme koncentracije (Kennewell i Beauchamp, 2007), a time unapređuju kvalitetu obrazovanja (Thompson i Flecknoe, 2003). To pokazuje da su pametne ploče fleksibilne i raznovrsne, čak su prihvaćene kao pomagalo koje na različite načine olakšava učenje u smislu, primjerice, učinkovitije multimedijske prezentacije, bolje produktivnosti, poticajnog unapređenja nastavnih planova i uporabe nastavnih izvora, kao i unapređenja interakcije za vrijeme sata. U nacionalnoj i internacionalnoj literaturi objavljena su brojna istraživanja o korištenju PP (Ateş, 2010; Gursul i Tozmaz, 2010; Hennessy, Deaney, Ruthven, i Winterbottom, 2007), provedena u različitim disciplinama i razmjerima. U njima se navode prednosti koje pametne ploče pružaju i problemi koji nastaju pri njihovoj uporabi. U tom smislu Yıldız i Tüfekçi (2012) ističu da su pametne ploče, kao sastavni dio obrazovnog procesa, jedan od najučinkovitijih i najprivlačnijih sredstava, pa bi se njima podjednako trebali koristiti nastavnici i učenici. U raznim je istraživanjima naglasak na prednostima pametnih ploča, osobito kada su u pitanju: postizanje boljeg uspjeha, ušteda vremena, povećanje motivacije i privlačenje pozornosti (Burke, 2010; Çoklar i Tercan, 2014; Digregorio i Sobel-Lojeski, 2010; Lutz 2010; Warnock, Boykin, i Tung, 2011;). Takvi rezultati sugeriraju da uporaba pametnih ploča u nastavnom procesu bitno pridonosi kontekstu koji čine nastavnik, učenik i rezultati učenja.

Štoviše, kada se neka istraživanja o toj problematici detaljnije pogledaju, može se vidjeti da uporaba pametnih ploča u različitim razredima i na različitim satima dovodi do različitih rezultata. U istraživanju koje je proveo Ekici (2008), uspoređuje se učinak pametnih ploča na uspjeh u matematici s onim postignutim tradicionalnim metodama. Dobiveni rezultati pokazuju da pametne ploče pozitivno utječu na uspjeh i dovode do permanentnog učenja. No, u istraživanju što ga je proveo Tataroğlu (2009) utvrđeno je da u nastavi matematike uporaba pametnih ploča uopće nema učinak na školski uspjeh učenika i njihovu samoučinkovitost. Dakle, iako pedagozi tvrde da pametne ploče pozitivno utječu na uspjeh, stajalište, motivaciju i mnoge druge čimbenike, a rezultati koji se na njih odnose nisu potpuno jasni, potrebna su dodatna istraživanja u tom smislu. Štoviše, kada se uzme u obzir da tehnološki razvoj izravno utječe na nastavnu praksu, vidi se kako je nužno utvrditi učinak takvih tehnoloških mogućnosti na nastavne aktivnosti.

Cilj i važnost istraživanja

Cilj je ovog istraživanja utvrditi učinak koji primjena pametnih ploča ima na školski uspjeh s obzirom na proces integracije tehnologije u nastavu. Jedan od temeljnih ciljeva u kontekstu turskog projekta Pokret za poboljšanje mogućnosti i unapređenje tehnologije jest proširiti uporabu pametnih ploča na sve školske razrede. Stoga je ovo istraživanje provedeno da bi se utvrdila učinkovitost državnog ulaganja s pomoću

uvida u mišljenja nastavnika i učenika. Istraživački se podatci smatraju značajnima jer otkrivaju razinu učinkovitosti u odnosu na trud i rad, a upozoravaju na određene zahtjeve. Od ovog se istraživanja, prema tome, očekuje da dopuni relevantnu literaturu i praktično pridonese integraciji tehnologije u nastavu. Najdojmljiviji je dio istraživanja način prikupljanja, analize i tumačenja podataka jer se u njemu koristi jedna drugačija metoda, poznata kao multikomplementarni pristup (MkP). Pregledom literature utvrđeno je da brojna istraživanja doista uključuju mješovitu metodu (Creswell i Plano Clark, 2007; Esteves i Pastor, 2004; Onwuegbuzie i Combs, 2011; Onwuegbuzie i Dickinson, 2008; Onwuegbuzie i Johnson, 2006), koja se prepoznaje kao jedan od triju glavnih pristupa u istraživanju (kvantitativno, kvalitativno i istraživanje mješovitom metodom) (Johnson, Onwuegbuzie, i Turner, 2007), a definira se kao miješanje ili kombiniranje kvalitativne i kvantitativne tehnike i pristupa u jednom istraživanju (Johnson i Onwuegbuzie, 2004); prema gruboj procjeni, broj takvih istraživanja bit će sve veći u budućnosti. No, ova se MkP donekle razlikuje od mješovite metode, kao što se može vidjeti u dijelu rada u kojem su opisane njezine pojedinosti.

Trofazno istraživanje nije uobičajeno, a zahvaljujući multikomplementarnom pristupu moguće je dobiti opće, pouzdane i valjane rezultate. Upravo zbog toga se i kvalitativnim i kvantitativnim podatcima pridaje velika i jednaka važnost, a svi se podatci objedinjuju da bi se bolje shvatio određeni problem. U ovom su istraživanju o primjeni pametnih ploča kao glavnom istraživačkom problemu definirani sljedeći ciljevi: provesti metaanalitički i tematski pregled da bi se dobili pretkomplementarni podatci, utvrditi postojeće praznine s pomoću pretkomplementarnih podataka, provesti drugu fazu da bi se dobili postkomplementarni podatci, kombinirati rezultate iz prvih dviju faza i dati preporuke s obzirom na njihovu komplementarnost. Imajući u vidu navedene istraživačke ciljeve, provedene su metaanaliza i tematska analiza o primjeni pametnih ploča u nacionalnom i internacionalnom kontekstu. Osim toga, provedeno je eksperimentalno istraživanje i tematsko istraživanje s pomoću intervjua da bi se kompletirala analiza dokumenata i eliminirale njezine praznine. U trećoj su fazi rezultati metaanalize i tematske analize uspoređeni s rezultatima eksperimentalnog i tematskog dijela istraživanja. Taj trofazni proces, koji obuhvaća i kvalitativne i kvantitativne rezultate, pridonosi valjanosti i pouzdanosti istraživanja. Dakle, polazeći od glavnog istraživačkog cilja, specificirani su sljedeći problemi s obzirom na mulitkomplementarni pristup:

1. Da bi se dobili pretkomplementarni podatci u prvoj istraživačkoj fazi predložena su sljedeća istraživačka pitanja:
   a. U kojoj mjeri pametne ploče utječu na školski uspjeh u kontekstu *metaanalitičkog pregleda zasnovanog na dokumentarnoj analizi*? (Tablica 1)
   b. Kakav je učinak uporabe pametnih ploča na školski uspjeh u kontekstu *metaanalitičkog pregleda zasnovanog na tematskoj analizi*? (Slike 3, 4, 5)
2. Da bi se dobili postkomplementarni podatci u drugoj istraživačkoj fazi, predložena su pitanja:

a. Postoji li značajna razlika između rezultata posttesta u eksperimentalnoj i kontrolnoj grupi u odnosu na uporabu pametnih ploča u nastavi matematike? (Tablica 2)
b. Kakav je učinak uporabe pametnih ploča na školski uspjeh u odnosu na stajališta učenika? (Slike 6, 7)

6. Da bi se dobili komplementarni podatci u trećoj istraživačkoj fazi, predloženo je sljedeće istraživačko pitanje:
   a. Nadopunjuju li se međusobno pretkomplementarni i postkomplementarni podatci dobiveni sintezom iz prve i druge faze i je li to integrativno?

Metoda

Ovo je istraživanje provedeno s pomoću jednog novog pristupa, poznatog kao MkP, a moguće ga je definirati kao pristup pri kojem se primjenjuju razni programi za analizu (SPSS, MetaWin, CMA, Nvivo, Maxqda, itd.). Kvalitativni i kvantitativni podatci holistički se kombiniraju da bi se dobili sveobuhvatni, valjani i pouzdani rezultati (Batdı, 2016). Dakle, istraživanje se provodi u tri faze. U prvoj su fazi pretražena istraživanja o korištenju pametnih ploča s pomoću metoda kao što su dokumentarna analiza/pregled/kompilacija (meta-analiza i tematska analiza) da bi se otkrile postojeće praznine u istraživanju. Prva se faza tog pristupa (MkP) zasniva na konstruktivizmu, čiji su pioniri Piaget, Bruner, Vygotsky, Dewey, Gestalt i Glasersfeld. Prema tome, ovdje se koriste pretkomplementarni podatci, umjesto onih prijašnjih konstruktivističkih. Glavni je cilj, dakle, novu informaciju dodati prethodnoj informaciji u toku učenja. Drugim riječima, kada se pretražuje određena tema, potrebno je pregledati sva istraživanja sa sličnim temama. Pregledom je moguće identificirati praznine, a informacija prikupljena u toj fazi odnosi se na pretkomplementarne podatke. U ovom smo istraživanju najprije nastojali pregledati sva istraživanja o uporabi pametnih ploča (nacionalni/internacionalni pretraživači ProQuest Dissertations and Theses (PQDT), the Higher Education Council National Thesis and Dissertation Center, Google Scholar, Ebscohost-Eric, Francis Online Journals i ScienceDirect) za razdoblje od 2000. do 2015. Polazeći od pregleda literature o primjeni pametnih ploča, obuhvaćena su 24 istraživanja, osobito ona u kojima su provedeni predtest i posttest, i ona koja sadrže deskriptivne podatke ($\bar{x}$, ss, n) koji omogućuju izračun usporednih veličina učinka. Podatci o istraživanju, kao što su autorovo ime, godina izdanja, područje istraživanja, navedeni su u Obrascu za metaanalitičko prikupljanje podataka (Prilog 1). Istraživanja su odabrana među 640 teza i članaka. Ukupan uzorak za eksperimentalnu grupu u tako odabranim istraživanjima (n=24) treba promatrati kroz broj 1036, odnosno 986 za kontrolnu grupu. Kada se razmatra ukupan broj za obje grupe, vidi se da su spomenutim istraživanjima obuhvaćena 2022 stajališta ispitanika, a to pak znači da ovo istraživanje obuhvaća velik uzorak, i da se njegovi rezultati mogu generalizirati i smatrati sveobuhvatnim. Za analizu podataka koristili su se statistički program za sveobuhvatnu metaanalizu (CMA) i program MetaWin. Može se vidjeti da je

distribucija veličine učinka veća od očekivane promjene zbog pogreške u uzorkovanju (Lipsey i Wilson, 2001), pa se koristio model slučajnih učinaka (REM). Rezultati su vrednovani prema Cohenovoj klasifikaciji (1992). Međuocjenjivačka se pouzdanost računa s pomoću formule [konsenzus/(konsenzus + disenzus) x 100], prema prijedlogu Miles i Huberman (1994), a njezin je rezultat ovdje iznosio 100 %.

Proveden je također tematski (uporaba pametnih ploča) pregled da bi se obogatili pretkomplementarski podatci u prvoj fazi i proširio opseg istraživanja. Primjena različitih izvora za prikupljanje podataka osigurava raznovrsnost, te povećava unutarnju valjanost (Yıldırım i Şimşek, 2005), odnosno pouzdanost i uvjerljivost istraživanja. S tim je ciljem 14 nacionalnih i internacionalnih istraživanja (teze i članci) pretraženo i prikupljeno putem dokumentarnog pregleda, zasnovanog na analizi sadržaja koji je čitateljima jasno prezentiran (Yıldırım i Şimşek, 2008). Do analiza se došlo s pomoću programa Maxqda. Članci su u tekstu kodirani kao „A", radovi unutar *ProQuest Dissertations and Theses* kao „PQDT", ostali radovi kao „T", a članci iz *ScienceDirect database* kao SD kada su izravno navođeni citati iz istraživanja unutar spomenutih baza da bi se potkrijepili odgovarajući kodovi. Dodani su također brojevi istraživanja i stranica s citatima (npr. PQDT1-94: 94. stranica rada u kodovima *ProQuest Dissertations and Theses* kao 1). Što se tiče pouzdanosti u procesu analize podataka, izračunate su vrijednosti slaganja (Cohen Kappa) onih koji su kodirali podatke (McHugh, 2012; Viera i Garrett, 2005); protumačene su kao ,692-,777, što znači „dobra razina slaganja".

Slika 1

Istraživački se proces nastavio drugom fazom multikomplementarnog pristupa (MkP), koja uključuje postkomplementarne podatke, nakon što je pregledana literatura i dobiveni su pretkomplementarni podatci o primjeni pametnih ploča (Slika 1). U ovoj se fazi koristila eksperimentalna dimenzija za dovršetak metaanalize i tematske analize utemeljene na analizi dokumenata, te za uklanjanje identificiranih praznina. U prvoj je fazi utvrđeno da se najveće poteškoće doživljavaju u nastavi matematike, a da je broj istraživanja u tom području dostatan za provedbu analize. Stoga je odlučeno da će se uključiti eksperimentalna dimenzija kada je u pitanju nastava matematike. Međutim, smatra se da je broj istraživanja povezanih s nastavom drugih predmeta manji i takva je nedostatnost podataka problem za postizanje ciljanog integriteta.

Zbog eksperimentalnog predtesta i posttesta s kontrolnom grupom istraživanje je obuhvatilo radnu grupu od 135 učenika devetog razreda jedne srednje škole u Elazığu u Anadoliju, u školskoj godini 2014./2015. Učenici su neutralno određeni s pomoću *cluster* analize, koja je obuhvaćala njihove zaključne ocjene iz matematike, fizike, kemije i biologije u prvom polugodištu (Prilog-2). Kada se pogleda tablica u Prilogu-2, može se vidjeti da ne postoji značajna razlika u njihovim rezultatima kada je u pitanju uspjeh iz matematike, fizike, kemije i biologije. Može se, dakle, reći da su grupe neutralno formirane prije početka eksperimentalnog procesa. Nadalje, tema „Funkcije" predstavljena je eksperimentalnoj grupi iz sedmog razreda s pomoću pametnih ploča

za vrijeme nastave matematike u drugom polugodištu školske godine 2014./2015. Nakon provedbe predtesta i pos-testa, podatci su uspoređeni, a predstavljeni su u raspravnom dijelu ovog rada. Kao alat za prikupljanje podataka koristili su se testovi za vrednovanje školskog uspjeha, a dobiveni su podatci analizirani s pomoću programa SPSS-17 i TAP. Utvrđeno je da prosječna težina na testu s ukupno 25 pitanja iznosi ,353, a da koeficijent pouzdanosti iznosi KR-20 od ,789.

Eksperimentalnoj dimenziji dodana je *kvalitativna* dimenzija u drugoj fazi multikomplementarnog pristupa kao doprinos spektru istraživanja, njegovoj pouzdanosti i podatcima prikupljenim na temelju učeničkih mišljenja. Za vrednovanje podataka koristio se model akcijskog istraživanja. Radna je grupa obuhvaćala 12 učenika s različitim uspjehom - „slab$_{(L)}$, srednji$_{(M)}$ i dobar$_{(G)}$" – odabranih iz eksperimentalnog dijela (maksimalne razlike uočene pri uzorkovanju). Pritom je moguće detaljno definirati slučaj svakog učenika, identificirati dodirne točke u njihovim stajalištima, te pokazati njihove različite karakteristike (Patton, 2002). Radnim je grupama predstavljen polustrukturirani intervju, koji je razradio autor uz pomoć stručnjaka. Učenici su kodirani kao 8G$_{M}$ (A ***M***ale učenik s ***G***ood dobrim uspjehom pod brojem ***8***), a u tekstu su navedeni citati koji su izvučeni iz njihovih stajališta. Citati pridonose vanjskoj valjanosti, a odnose se na strategiju prenosivosti u kvalitativnim istraživanjima, čiji je cilj jasno otkriti i detaljno opisati slučajeve (Yıldırım i Şimşek, 2008). Podatci dobiveni s pomoću obrazaca za intervju analizirani su zahvaljujući programu Maxqda 11, a vrijednosti slaganja među ocjenjivačima kretale su se u rasponu od ,800 do ,821, što ukazuje na „dobro/vrlo dobro slaganje".

Završni je dio istraživanja na temelju multikomplementarnog pristupa (MkP) obuhvaćao sintezu. U toj se fazi kombiniraju pretkomplementarni i postkomplementarni podatci o korištenju pametnih ploča da bi se dobio holistički uvid u istraživanje jer Mertens (2011) u svom istraživanju navodi da je u istraživanjima mješovitom metodom potrebno integrirati metode, analizu ili izvješćivanje o rezultatima. Nadalje, u ovom se konkretnom slučaju sinteza rezultata ne promatra samo s pomoću kombiniranja pretkomplemnetarnih i postkomplementarnih podataka. Sönmez (2008) naglašava da svaki stvoreni integritet ne predstavlja sintezu, a to je zato što sinteza zahtijeva karakteristike kao što su inovacija, originalnost, inventivnost i kreativnost. U ovom se istraživanju jedinstvenim i kreativnim trendom smatra primjena pregleda literature za dobivanje pretkomplementarnih podataka o temi – cilju, provedba originalnog (eksperimentalnog) istraživanja i kombinacija rezultata proizašlih iz tih dvaju procesa. Inače, potpunu povezanost nije baš moguće postići iako je glavni cilj istraživanja doći do potpune informacije. S obzirom na spomenuto, Russell (1912) tvrdi da je dolaženje do potpune istine potrebno smatrati sporazumnom prilagodbom na dugom putu, te dodaje da posljednja točka do koje stižemo nije krajnji, već korak bliže do potpune istine. Posljednji korak, dakle, uvijek ostaje izvan dosega jer je svako istraživanje, svaki napredak i svaki razvoj u znanosti korak ispred onog do kojeg se već stiglo. Koraci su pritom od pomoći, ali samo da bi se približilo komplementarnoj informaciji u posljednjoj fazi.

Rezultati

Ovo istraživanje obuhvaća tri faze MkP-a. Meta-analitički i tematski pregledi na temelju dokumentarne analize provedeni su u prvoj fazi, a do eksperimentalne i tematske primjene došlo je u drugoj fazi. U Tablici 1 prikazani su rezultati metaanalize koji se odnose na učinke primjene pametnih ploča na školski uspjeh u usporedbi s tradicionalnim metodama. Utvrđeno je da je distribucija veličine općeg učinka u istraživanjima koja problematiziraju školski uspjeh heterogena, prema REM (Q=25,790, df=23, *p*>,05). Osim toga, podatak o značajnoj vrijednosti statističkog testa homogenosti (Q test) i uvid u to da je distribucija veličine učinka veća od očekivane promjene zbog pogreške pri uzorkovanju (Borenstein, Hedges, Higgins i Rothstein, 2009; Lipsey i Wilson, 2001) navode istraživača na provedbu analize prema REM. Izračunato je da veličina učinka iznosi ES=0,619 – kod znatne veličine učinka prema Cohenovoj (1992) klasifikaciji. Štoviše, utvrđena je z vrijednost od 4,955 kada se određuje statistička značajnost prema z-testu, ali nema statističke značajnosti u odnosu na p vrijednost (*p*=0,33).

Tablica 1

U metaanalitičkim istraživanjima, od neobjavljenih nul istraživanja zahtijeva se uklanjanje statističke značajnosti iz metaanalitičkih rezultata. Drugim riječima, radi se izračun fail-safe broja (FS_N) da bi se u metaanalizi otklonila prepreka za objavljivanje (Rosenthal, 1979) (Tablica 1). U ovom istraživanju vrijednost FS_N pokazuje da bi 1425,2 istraživanja o učinku pametnih ploča na školski uspjeh trebalo uključiti u analizu da bi se dobila nulta veličina učinka. Budući da je taj broj vrlo velik, može se tvrditi da prepreka za objavljivanje u ovom istraživanju ne utječe na pozitivnu veličinu učinka (Cheung i Slavin, 2011), te da su analize iznimno pouzdane.

Rezultati o stajalištima prikupljeni od ispitanika na temelju dokumentarne analize

Pregledana su istraživanja o uporabi pametnih ploča na nacionalnoj i internacionalnoj razini da bi se dobili pretkomplementarni podatci dodavanjem tematskog aspekta metaanalizi. S tim su ciljem detaljno razmatrana stajališta ispitanika u sličnim istraživanjima. Kvalitativni su rezultati klasificirani prema različitim temama/kodovima, koji su pretvoreni u modele i predstavljeni pod trima podnaslovima.

Slika 2

Prvi model, kreiran u skladu sa stajalištima ispitanika o uporabi pametnih ploča, obuhvaća teme pod naslovom „pozitivni učinci uporabe pametnih ploča na kognitivna, afektivna i društvena područja". Kodovi koji se odnose na kognitivno područje pokazuju da primjena pametnih ploča „odgovara brojnim tipovima inteligencije, predstavlja vizualno bogatstvo zbog videa i animacije, te omogućuje korisniku da uspješno kreira proizvode". Jedno od istraživanja, kodirano kao T3-73, obuhvaća

izričaje, kao što su: „*… pametne su ploče doista korisne... mogu se obratiti učenicima s različitim tipovima inteligencije...*", što se odnosi na srodne kodove. Također su navedeni neki kodovi povezani s afektivnim područjem jer primjena pametnih ploča „povećava samopouzdanje te motivira nastavnike i učenike". Izričaji koji se mogu citirati za te kodove preuzeti su iz istraživanja, kodiranog kao PQDT12-94, a specificirani su kao „motivacija nastavnika veća je kada se koriste pametnim pločama, a to također povećava motivaciju učenika." Posljednja tema, koja se odnosi na društveno područje, sadrži određene podteme, kao što su pametne ploče „…omogućuju suradničko istraživanje, povećavaju interakciju za vrijeme nastave i omogućuju učenicima da uče jedni od drugih ". Citat iz istraživanja pod kodom A18-502 pokazuje da *„moji se učenici koriste pametnim pločama da bi interaktivno uredili i nadzirali svoj rad..".* Taj citat ilustrira prethodno navedeno.

Slika 3

Kodovi, kreirani na temelju učeničkih stajališta o nastavnom okruženju, prikazani su s pomoću modela na Slici 3. U kontekstu teme o nastavnom okruženju primjećuju se kodovi kao što su „uspostava nastavnih okruženja za uživanje i kreiranje eksperimentalnih medija". Oni se zasnivaju na citatima iz istraživanja pod kodovima PQDT1-94 i T14-51, koji bilježe *„učenici pokazuju da su aktivni i spremni sudjelovati u nastavi"* i *„To je koristan proces zbog vizualnosti. Promatrati eksperimente na videosnimkama omogućuje lakše razumijevanje teme."* Kodovi „postići pedagošku svjesnost" i „poticati učenje o učenju", preuzeti iz citata prema istraživanju pod kodom PQDT8-75, temelje se na izričajima, kao što su *„interakcija između nastavnika i učenika treba biti vrlo dobra..."* i *„ključno je imati znanje o učenju i učiti kroz iskustvo u nastavnom procesu"*.

Slika 4

Slika 4 obuhvaća teme koje se odnose na probleme i preporuke u vezi s uporabom pametnih ploča. Neki se kodovi, povezani s problemima primjene pametnih ploča, mogu definirati kao „uzrokovanje pospanosti i nevoljkosti zbog sumorne atmosfere, izazivanje disciplinskih problema u toku tehničkog kvara". Navedeni su kodovi iz istraživanja T14-54 preuzeti iz citata *„…mračna i zagušljiva atmosfera na satu čini učenike bezvoljnima."* U sklopu teme o preporukama iz istraživanja se citiraju kodovi, kao što su *„sadržaj treba proširiti uvodeći obilje materijala."*, *„nastavnicima je potrebna poduka o uporabi pametnih ploča"*, te *„potrebno je pripremiti interaktivniji sadržaj"*. *„...S interaktivnijim se sadržajem može privući pozornost učenika..."* iz T15-58 i *„…mogu se održati seminari za nastavnike o primjeni pametnih ploča i računala."* iz T18-48 predstavljaju citate koji su osnova za slične kodove.

Eksperimentalni rezultati o učinku uporabe pametnih ploča na školski uspjeh

Ovdje je prikazana druga faza istraživanja, zasnovanog na MkP-u, a provodi se nakon dobivanja pretkomplementarnih podataka s pomoću metaanalize i tematskog

pregleda u prvoj fazi. Budući da je u dijelu rada o metodi iznesen razlog za preferiranje nastave matematike kada je u pitanju eksperimentalna dimenzija istraživanja, u daljnjem je dijelu teksta predstavljen učinak pametnih ploča na školski uspjeh u nastavi matematike. Primijenjen je t-test za neovisne uzorke da bi se utvrdila razina značajnosti u rezultatima posttesta u radnoj grupi. Najprije je testirana homogenost varijanci, te je utvrđeno da postoji distribucija homogenosti (F=1,787; p>,05).

Tablica 2

Utvrđena je značajna razlika između školskog uspjeha u eksperimentalnoj i kontrolnoj grupi, također između srednjih vrijednosti u objema grupama od 1,52 u korist eksperimentalne grupe ($\bar{X}_{eksperimentalna}$=9,00; $\bar{X}_{kontrolna}$=7,48). Kada se razmotre t i p vrijednosti da bi se utvrdila značajnost razlike između tih grupa, izračun t vrijednosti iznosi t=1,787, p<,05. Činjenica da je značajnost manja od p=,05, ukazuje na razliku između rezultata koje su učenici postigli na testu, što otkriva da primjena pametnih ploča u nastavi matematike ima pozitivan učinak na školski uspjeh u usporedbi s tradicionalnim pristupom. Štoviše, veličina učinka u eksperimentalnom istraživanju iznosi ES=0,530, što je srednja vrijednost, prema Cohenovoj (1992) klasifikaciji. Može se konstatirati da uporaba pametnih ploča u nastavnom okruženju pozitivno utječe na uspjeh.

Tematski rezultati dobiveni na temelju stajališta ispitanika nakon eksperimentalne primjene

Tematski aspekt, korišten za dobivanje postkomplementarnih podataka, pridodan je u ovom istraživanju koje se zasniva na MkP-u. U tom su kontekstu prikupljena stajališta učenika o primjeni pametnih ploča u nastavi matematike da bi se potkrijepili eksperimentalni rezultati i upotpunili podatci. S pomoću sadržajne analize analizirani su podatci o učeničkim stajalištima unutar određenih kodova i tema. S tim su povezane teme dolje predstavljene s pomoću modela pod naslovom „*pozitivni učinci pametnih ploča te problemi i preporuke u vezi s uporabom pametnih ploča*".

Slika 5

Na Slici 5 navode se pozitivni učinci primjene pametnih ploča u nastavi matematike. Vidljivo je da su kreirane teme, kao što je učinak pametnih ploča na „stajalište/motivaciju, aspekte vizualne i tehnološke sposobnosti ". Dok su kodovi o korištenju pametnih ploča, kao što je „…čine matematiku pristupačnijom, sigurno čine nastavni proces detaljnijim i uvode praktičnost", dojmljivi pod temom stajalište/motivacija, kodovi izraženi kao „…pametne ploče imaju videoaplikacije koje omogućuju permanentno učenje, kreiraju raznobojne prezentacije i čine da događaje percipiramo stvarnijima" uočljivi su unutar teme vizualnih aspekata. U kontekstu tehnološkog postignuća, kreirani su kodovi, kao što je „…pametne ploče razvijaju tehnološke vještine kod učenika, to im omogućuje mrežno pretraživanje, nastavnicima i učenicima omogućuje primjenu tehnologije". Srodne su teme i kodovi preuzeti iz citata kao što

je sljedeći: „*..u usporedbi s prijašnjom nastavom, nastava u kojoj se rabe pametne ploče bogata je u vizualnom i sadržajnom smislu, pa vidim da to olakšava razumijevanje.*" ($5G_F$); „*…pametne ploče mi omogućuju da mnogo istražujem, imam mogućnost tražiti teme koje me zanimaju zbog internetske veze.*" ($8O_M$).

Slika 6

Na Slici 6 primjećuju se stajališta ispitanika o primjeni pametnih ploča u smislu „općih problema povezanih s primjenom pametnih ploča; problema u vezi s nastavnicima – učenicima i preporuka". „Pametne ploče se kasno otvaraju/zatvaraju ili problemi sa zamrzavanjem, mogu zakazati pri instaliranju/pokretanju USB-a, njihov ekran na dodir može biti oštećen, moguć je izostanak internetske veze u učionici" predstavljaju kodove koji se odnose na temu općih problema. Mogu se navesti neki od citata preuzeti iz stajališta učenika, primjerice „*Imali smo brojne tehničke probleme, kao što su oštećenje električnih utičnica, nedostatak internetske veze, problemi sa zamrzavanjem…*" ($7G_F$) ili „*…brzina veze, tehnički nedostatci, stalno otvaranje/zatvaranje pametnih ploča mogu uzrokovati kašnjenja i gubitak vremena...*" ($5M_M$). Međutim, pojavili su se kodovi o problemima nastavnici – učenici, kao što su: „Učenici se možda ne znaju učinkovito koristiti pametnim pločama za domaću zadaću, neznanje o korištenju pametnih ploča može uzrokovati oštećenja, pametne ploče mogu dovesti do gubitka vremena i pametne ploče mogu nastavnike učiniti lijenima." Ti se kodovi temelje na citatima preuzetim iz izraza jednog učenika pod kodom$1G_{M,}$ koji je istaknuo „*ne razmišljam o pozitivnom učinku primjene pametnih ploča na pisanje domaće zadaće.*", odnosno $3M_M$ koji je naveo da „*više vremena u toku sata prođe dok nastavnik otvori dokument na ploči ili pozove nekog da pokrene ploču jer on/ona ne zna kako se koristiti pametnom pločom.*"

Na Slici 6 zabilježene su, također, neke preporuke o korištenju pametnih ploča. Ti su kodovi formulirani kao „korisnici trebaju biti upoznati s korištenjem pametnih ploča i o tome detaljno poučeni, pametne je ploče potrebno povremeno popravljati, a informatičke tečajeve o primjeni pametnih ploča uvesti u deveti razred." Oni se zasnivaju na sljedećim citatima: učenik pod kodom $8L_M$ primjećuje „*u početku sam se brinuo za korištenje pametne ploče, ali to može biti vrlo korisno ako se provede poduka o primjeni pametnih ploča …*", a učenik pod kodom $11M_F$ primjećuje da „*uvijek postoje problemi s pametnim pločama. Ponekad se zamrzavaju ili su zaražene virusom. Pametne se ploče, dakle, moraju redovito održavati.*"

Rasprava i zaključak

U ovom se istraživanju problematizira učinak primjene pametnih ploča na školski uspjeh u kontekstu procesa integracije tehnologije u nastavu. Njegov je opseg proširen zahvaljujući MkP-u, a za potrebe prikupljanja podataka pridodane su mu metaanalitička, tematska i eksperimentalna dimenzija. Pritom je u prvoj fazi proveden metaanalitički i tematski pregled da bi se dobili pretkomplementarni podatci o uporabi

pametnih ploča. S pomoću rezultata metaanalize utvrđeno je da veličina učinka rezultata povezanih sa školskim uspjehom iznosi 0,619, prema REM. To je srednja vrijednost, pri čemu je utvrđeno da je ona pozitivna i značajna.

Osim toga, rezultati tematskog pregleda pokazuju da pametne ploče pozitivno utječu na kognitivno, afektivno i društveno područje. Kad smo već kod toga, istraživanje autora Amiri i Sharifi (2014) pokazalo je da uporaba pametnih ploča pozitivno utječe na vještinu pisanja, te da se učenici počinju koristiti raznovrsnijim prilozima i pisati jasnije rečenice upravo zbog primjene pametnih ploča. Štoviše, one također utječu na nastavno okruženje tako što kreiraju ugodne i realistične medije, pa učenicima daju mogućnost da nauče kako učiti. Wood i Ashfield (2007) su pritom došli do sličnih rezultata u jednom od svojih istraživanja u kojem su promatrali realizaciju i brzinu nastave nakon uporabe interaktivnih bijelih ploča, to jest pametnih ploča. Nastavni je proces u potpunosti olakšan pametnim pločama. S druge strane, zabilježeni su određeni problemi u vezi s primjenom pametnih ploča, kao i preporuke u vezi s njima. Neki se od negativnih aspekata mogu formulirati na sljedeći način: sumorno ozračje u učionici, nedostatak sadržaja, problemi s vezom i softverom. Spomenute se negativnosti osobito primjećuju u nastavi matematike. Slični se rezultati javljaju u nekim istraživanjima navedenim u relevantnoj literaturi (Kevser i Çetinkaya, 2013; Schmid, 2008). U jednom je istraživanju o učinkovitosti projekta *Pokret za poboljšanje mogućnosti i unapređenje tehnologije* zaključeno da nastavnici ne raspolažu dostatnim kompetencijama za primjenu tehnoloških uređaja, te da ne primjenjuju tehnologiju koja odgovara cilju (Özkan i Deniz, 2014). Stoga je moguće preporučiti održavanje seminara za nastavnike ili interno stručno obrazovanje o primjeni tehnologije i/ili osobito pametnih ploča. Rezultati istraživanja Manny-Ikan i Dagan (2011), usmjerenog na nužnost metodičke poduke za nastavnike, pokazali su se sličnima kada su u pitanju navedene preporuke. U našem je istraživanju, u tom smislu, također razmatrana preporuka u vezi s nužnim informiranjem učenika o primjeni pametnih ploča. Spomenute se preporuke mogu još potkrijepiti istraživanjem o primjeni pametnih ploča u nastavi matematike, što su ga proveli Çoklar i Tercan (2014). Rezultati metaanalize i tematskog pregleda u ovom istraživanju, dakle, ukazuju na to da obje te kategorije imaju dodirnu točku u kojoj se promatraju pozitivni učinci pametnih ploča na kognitivnu, afektivnu i društvenu dimenziju.

Nakon prve faze istraživanja o učinku pametnih ploča na školski uspjeh, otkrivena je srednja, ali pozitivna veličina učinka, a analize ovdje uključenih istraživanja pokazale su da veličina učinka, osobito u nastavi matematike, iznosi ,404, što znači da je mala. Tako mala vrijednost navodi istraživača na detaljniju analizu problema. Uporaba pametnih ploča u nastavi matematike može se doimati donekle teškom, ali je u istraživanju utvrđeno da je potrebno eliminirati praznine koje su utvrđene s pomoću pretkomplementarnih podataka, pa je tijekom druge faze tog istraživanja, provedenog s pomoću MkP-a, uvrštena eksperimentalna primjena u nastavu matematike. Nadalje, primijećeno je da postoje brojna istraživanja o primjeni pametnih ploča u

srednjoškolskoj nastavi matematike, ali samo ih je nekoliko provedenih na toj razini; tako je provedeno eksperimentalno istraživanje s kontrolnom grupom s pomoću predtesta i posttesta u sklopu nastave stranog jezika u dvanaestom razredu da bi se dobili podatci nakon integracije (Prilog 1). Osim toga, kada se razmatraju istraživanja uključena u ovu analizu, primjećuje se da ih je većina povezana s nacionalnim i internacionalnim tezama, a ne člancima (Prilog 1). Ovo istraživanje može, stoga, pridonijeti otklanjanju nedostatka koji je utvrđen analizom pretkomplementarnih podataka.

U eksperimentalnom dijelu, provedenom radi upotpunjavanja pretkomplementarnih rezultata istraživanja utemeljenih na analizi dokumenata, tema „Funkcije" u nastavi matematike prezentirana je učenicima devetog razreda s pomoću pametnih ploča, kada je zabilježena značajna razlika između eksperimentalne i kontrolne grupe u korist one prve. Sličan rezultat o prednosti eksperimentalne grupe nalazimo u Linkovu (2012) doktorskom radu. Činjenica da je školski uspjeh bolji u eksprimentalnoj nego u kontrolnoj grupi, slična je rezultatima našeg istraživanja, pa se može reći da uporaba pametnih ploča pozitivno utječe na školski uspjeh. Deskriptivni rezultati nakon provedenog eksperimenta pokazuju da izračun veličine učinka u tom dijelu istraživanja iznosi 0,530, što se može tumačiti kao školski uspjeh eksperimentalne grupe u kojoj se pametne ploče više koriste. U relevantnoj literaturi nalazimo slične rezultate istraživanja na temu uporabe pametnih ploča (Dhindsa i Shahrizal-Emran, 2011; Heard, 2009; Yıldız i Tüfekçi, 2012).

U drugoj je fazi ovom istraživanju, koje se zasniva na MkP, pridodan tematski aspekt da bi se dobili što bogatiji podatci i što pouzdaniji rezultati. Zapaženo je pritom da zanimljiv i audiovizualni sadržaj povećava motivaciju, te da pametne ploče razvijaju pozitivna stajališta, osiguravaju nastavu s više pojedinosti, odnosno pružaju brojne mogućnosti nastavnicima i učenicima. Slični rezultati u prvoj i drugoj fazi istraživanja sugeriraju da rezultati odgovaraju jedni drugima i međusobno se nadopunjuju. Phelpsovo (2012) istraživanje može se navesti kao referenca za spomenute rezultate, prema kojem upotreba pametnih ploča pozitivno utječe na sudjelovanje učenika u nastavi. Armstrong i suradnici (2005) također su istaknuli važnost interaktivnih bijelih ploča u promidžbi kvalitetnih interakcija i interaktivnosti između učenika.

Završna faza istraživanja, provedenog prema MkP, obuhvaća sintezu. Drugim riječima, kao dio procesa, pretkomplementarni se podatci iz prve faze kombiniraju i povezuju s postkomplementarnim podatcima iz druge faze. Rezultati metaanalize iz prve faze – koji uključuju veličinu pozitivnog učinka pametnih ploča na školski uspjeh – i rezultati tematskog pregleda – koji uključuju veću motivaciju, doprinos društvenosti, usvajanje sposobnosti i utvrđivanje određenih problema – slični su u objema fazama. Eksperimentalni rezultati pokazuju da je učinak primjene pametnih ploča na školski uspjeh veći kada se usporedi s tradicionalnim pristupima. Ti su rezultati također slične prirode kao rezultati metaanalize i tematskog pregleda iz prve faze. Tematski se aspekt ovog istraživanja s pomoću MkP s kojim se eksperimentalni

dio nadopunjuje i upotpunjuje odnosi na stajališta učenika. Upravo se, zahvaljujući njima, čini kako primjena pametnih ploča uključuje zanimljiv i audiovizualni sadržaj koji povećava motivaciju, razvija pozitivno stajalište o nastavi, te ima videoaspekt koji omogućuje permanentno učenje. Bahadur i Oogarah (2013) se također pozivaju na bolje sudjelovanje i veće zadovoljstvo učenika u nastavi kada se koristi bijela ploča, pa zaključuju da se nastavnici slažu kako su bijele ploče učinkovito sredstvo. Spomenuti rezultati znače da je druga istraživačka faza sasvim komplementarna i integrativna. Dakle, rezultati svake faze (prekomplementarna i postkomplementarna) obuhvaćaju četiri različita analitička procesa, ističući da pametne ploče pozitivno utječu na školski uspjeh općenito. Nadalje, rezultati u vezi s problemima upotrebe pametnih ploča također su slični u objema fazama. Sličnost pokazatelja označava konzistentnost istraživačkih rezultata.

Slijedom komplementarnih istraživačkih rezultata, moraju se istaknuti neka značajna mjesta kada je u pitanju faza sinteze. Znanstveno značenje pojma sinteza pojašnjeno je u dijelu o metodi u smislu proizvodnje, oblikovanja, preporuke i stvaranja. Stoga se izrazi utemeljeni na sugestijama razmatraju u fazi sinteze. Činjenica da ne postoji mnogo istraživanja o temi primjene pametnih ploča u nastavi matematike ni na sveučilišnoj razini, može biti preporuka autorima da provedu nova istraživanja o toj temi. Štoviše, mogu se proširiti istraživanja o upotrebi pametnih ploča u sklopu projekta *Pokret za poboljšanje mogućnosti i unapređenje tehnologije*. S druge strane, u drugim se istraživanjima mogu pronaći rezultati koji se odnose na probleme u vezi s upotrebom pametnih ploča (Phelps, 2012; Riska, 2010; Tataroğlu, 2009), te preporuke o važnosti seminara i interne obuke. Beauchampovo (2004) istraživanje o primjeni interaktivnih bijelih ploča u tom smislu naglašava potrebu nastavnika da se pripreme za novu ulogu korisnika bijelih ploča prije nego što one uopće stignu. Prema tome, trenutno stanje ukazuje na nedostatnost kada su u pitanju programi stručnog osposobljavanja, pa se provedba takvog istraživanja može preporučiti. Kontinuiran tehnološki napredak pokazuje da je povremeno potrebno obnavljati studijske programe, kao i to da su kandidatima za obavljanje nastavničkog posla potrebni praktični tečajevi o upotrebi pametnih ploča da bi stekli dovoljno znanja i iskustva.

Tematski rezultati, prikupljeni na temelju stajališta učenika, ističu poteškoću kada je riječ o pripremi sadržaja s pomoću pametnih ploča. Nastavnike treba poučiti kako pripremati i dalje razvijati materijale. Interaktivne materijale za pametne ploče može pripremati komisija pri Ministarstvu obrazovanja, kao što je slučaj s udžbenicima koje priprema Ministarstvo da bi ih poslije slalo u škole na uporabu. Štoviše, pri pregledu literature primijećeno je da se u nekim istraživanjima nije koristila jedna od naprednih statističkih tehnika pod nazivom cluster analiza, koja se inače upotrebljava za formiranje eksperimentalnih i kontrolnih grupa, što upućuje na moguća ograničenja razmotrenih istraživanja upravo zbog tog nedostatka. Stoga se preporučuje primjena *cluster* analize u budućim istraživanjima (Akdemir, 2009). U nekim se istraživanjima

(npr. Buff, 2012) vidi da razlika u aritmetičkoj sredini (rezultati posttesta) ide u prilog kontrolnoj grupi. Međutim, ona nije statistički značajna (P=0,15>0,05). Program za metaanalizu tu vrijednost smatra negativnom i ukazuje na to da rezultat ide u korist kontrolne grupe. Dakle, primjena programa za metaanalizu, zajedno s programima kao što je SPSS, znači mogućnost precizne i točne evaluacije MKP-a. Pritom se, kada je istraživanje zasnovano na spomenutom pristupom (MkP), kao što prikazuje Slika 1, može primijetiti sljedeće: *polazeći od pretkomplementarnih podataka*, očigledno je da se korištenje pametnim pločama u nastavi matematike doima teškim, te da postoji ograničen broj istraživanja provedenih na srednjoškolskoj razini; *polazeći od postkomplementarnih podataka*, čini se da uporaba pametnih ploča pozitivno utječe na školski uspjeh unatoč problemima u primjeni; *polazeći od komplementarnih podataka,* predstavljene su određene preporuke za navedene probleme, imajući u vidu veću učinkovitost i produktivnost pri korištenju pametnim pločama.