The effect of technology supported teaching on students’ academic achievement: a combined meta-analytic and thematic study

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Abstract: This research aimed to enlighten the ambiguous relationship between technology supported teaching (TST) and students’ achievement. A meta-analysis was conducted incorporating the quantitative findings of 11 scientific studies derived from 245 theses and 386 articles. These addressed the effect of technology on students’ academic achievement nationally and internationally between 2005 and 2016. The results indicate that TST has a positive effect on students’ academic achievement. Furthermore, participants’ perceptions of this issue were thematically derived from 12 academic studies and these corroborated the quantitative findings. Learners should therefore be exposed to innovative technologies such as Web 2.0 and augmented reality technologies to effectively and adequately benefit from them as learning strategies. The results of both studies are discussed in detail and suggestions made for future research.

Keywords: technology supported teaching; TST; meta-analysis; thematic study; students’ academic achievement.


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1 Introduction

Information and communication technology (ICT) can play a significant role in supporting economic, social and educational changes (Kozma, 2008). ICTs are regarded as potential tools for change and innovation in education (Tezcî, 2009) and include computer applications, mobile technology and communication systems. Owing to ICT’s potential role in facilitating changes, it has been implemented in education to help teach concepts, phenomena and theories (Başkırcî et al., 2011). Thus, Heitink et al. (2016) have argued that the use of technology is important in teaching and learning because the rapid development of technological applications has enabled students to understand key concepts in education more clearly (Chauhan, 2017). Using technology, teachers and students can access specialised materials in multiple formats without encountering any major constraints relating to time and space. Furthermore, teachers can create knowledge and enrich teaching materials using the platforms provided by technology. Technology can also support new pedagogies which perceive learners as active participants (OECD, 2015). As noted by Chauhan (2017), students learn better when they are active participants and can relate the concepts they learn to their everyday lives.

In Organisation for Economic Co-operation and Development (OECD) countries, significant investments have been made to reinforce the role of technology in education (OECD, 2010). One of the main reasons for such investment is that the use of technology and media in education facilitates a range of innovative practices that incorporate ICT skills and promote digital and media literacy (Hobbs and Tuzel, 2017). Tondeur et al. (2016, p.111) point out that “…ICT is expected to transform education, thereby promoting 21st century skills.” Such skills include collaboration, communication, ICT literacy, citizenship, creativity, critical thinking, productivity and problem-solving (Voogt and Roblin, 2012). The question then arises as to whether such investments in technology fulfil expectations (OECD, 2010). This is a pertinent question when the magnitude of ICT investments in education systems is considered in relation to the limited budget held...
by underdeveloped and developing countries. It is therefore extremely important to investigate the extent to which technology supported teaching (TST) affects the teaching and learning process in terms of students’ academic achievement. Moreover, it is vitally important to determine the effect of technology on teaching and learning processes as this will provide decision makers and researchers with a roadmap to understand and justify the role played by technology in education.

2 Theoretical background

There are high expectations regarding the ability of technology to enhance education. Technology is perceived as a mediator that will help achieve a nations’ educational goals (Baser-Gulsoy, 2011). In this respect, it supports and enhances how teachers teach and learners learn (Aslan and Zhu, 2016; Chauhan, 2017; Drent and Meelissen, 2008; ISTE, 2008; Tamim et al., 2011). Chauhan (2017) conducted a meta-analysis on the impact of technology on the effectiveness of learning among elementary students and found that the score for such an effect was medium (0.546). However, Liao and Hao (2008) have shown that the effect size for the impact of technology on students’ learning is 0.06, which is trivial. Cuban (2001, p.178) noted that “The link between test score improvements and computer availability and use is even more contested.” Likewise, students’ frequent use of computers at school does not result in better learning outcomes. On the contrary, they often perform far worse (OECD, 2015). This finding was also supported by Zuzovsky (2013) who argued that the frequent use of computers may have a negative association with students’ achievements in school. As pointed out by Kadijevic (2015, p.985), “…the relationship between computer use and achievement is still puzzling.” Therefore, it is extremely important to clarify the relationship between technology and achievement if the effective deployment of technology is to be supported and teaching and learning processes enhanced. For this purpose, a quantitative meta-analysis will be conducted to establish the effect of technology according to scientific studies. The meta-analysis aims to incorporate the findings of several studies and clarify the relationship between technology and learning. In addition to the meta-analysis, a qualitative thematic analysis will be conducted to provide a more comprehensive understanding of the issue and support the findings of the meta-analysis.

2.1 Objectives of the study

This study has two objectives. The first is to investigate the effect size of TST on students’ academic achievement. This will be achieved through a meta-analytic study comprising the findings of 11 scientific studies from 245 theses and 386 articles from research conducted nationally and internationally between 2005 and 2016. The second objective is to use thematic analysis to explore participants’ perceptions regarding the use of technology supported education.

2.2 Research questions

This study therefore focused on addressing the following questions:

1 what is the effect size of TST on students’ achievement?
2 what are participants’ perceptions regarding the use of TST?
3 Method

In this study, TST refers to the general use of technology to support the teaching process rather than a specific form of technology such as augmented reality technology. The main reason for focusing on the effect of the general use of technology is that, based on an extensive literature review, the number of studies dealing with the effect of TST on students’ achievement is limited. Students’ academic achievement will also be defined in terms of course grades. Thus, this study focuses on identifying the extent to which TST influences students’ course grades by implementing both quantitative and qualitative analyses. For the quantitative analysis, a meta-analytic method was used to identify the effect size of TST on students’ achievement. The meta-analytic method is defined as a statistical technique that combines the findings of independent studies dealing with similar issues (Crombie and Davies, 2009). Key words in both Turkish and English, such as ‘Technology-enhanced learning on achievement’ and ‘The effect of technology-based learning on achievement’ were searched using databases such as ProQuest dissertations and theses (PQDT), the higher education council of Turkish Republic for national thesis and dissertation centre, Google scholar, Ebscohost-Eric, Taylor & Francis online and ScienceDirect search engines. In meta-analytic studies, the selection criteria play a substantial role in determining which studies should be included. Firstly, recent studies on the effect technology has on learners’ academic achievement were selected and defined as those taking carried out between 2005 and 2016. Secondly, care was taken to include experimental and control groups in the studies and sample sizes were also considered to calculate the effect sizes in different groups. The criteria of this study are therefore as follows: sample size (n) of the experimental and control groups, to calculate the effect sizes of the groups, mean (X), standard deviation (sd) and the 2005 to 2016 implementation period in which they were applied, nationally and internationally. Based on the results of the literature review, 11 studies (seven articles, three Master’s theses and one PhD dissertation) involving pre-test and post-test implementations, were chosen out of 245 theses and 386 articles. Thus, the population in this research consists of studies conducted on the use of TST both nationally and internationally, while the sample comprises theses and articles obtained from databases covering the period 2005 to 2016. No sampling method was therefore used to access all resources relating to TST.

A detailed form with three sections was prepared for the studies included in the quantitative part of the research. The first section, entitled ‘study identity’, included the study code, study title, author information and study year. Thus, ‘TN’ code refers to the thesis number, while ‘M’ code refers to the article number. The second section, entitled ‘study contents’, contained information on the courses, education levels and teaching period. Finally, the third section, entitled ‘study data’, included sampling sizes, mean and standard deviation values. The studies were formatted as [(Aslan, 2012)TN:300430, (Bahçeci, 2011)TN:289868, (Buran, 2005)TN:188055, (Oktay and Çakır, 2013)M22, (Erdemir, 2011)M17, (Gökova, 2010)TN:285079] for the purpose of meta-analytic assessment and then entered onto the form. Study characteristics must be identified in meta-analytic studies. In this research, these characteristics were defined as students’ education levels, the courses upon which studies were conducted, the implementation period of the studies, sample size, standard deviation and mean. Quantitative data analyses were conducted according to the study of effect. Therefore, the data obtained from combining the statistical data from independent studies had to be converted into a common unit of measure expressed.
as an effect size. Cohen’s (1992) classification level (0.20–0.50 small; 0.50–0.80 medium; over 0.80 large) was used to calculate the effect size. Statistical data analyses were conducted using comprehensive meta-analysis (CMA) and MetaWin programs. The fixed effects model (FEM) and random effects models (REMs) (Knapp and Hartung, 2000) were utilised in the statistical analysis. The coding reliability of all the studies in the meta-analysis was calculated by another academic scholar. The 100% reliability among assessors calculation formula \[ \text{consensus} / (\text{consensus} + \text{dissensus}) \times 100 \] by Miles and Huberman (1994) was used to calculate the reliability outcome which in this research was 100%.

For the qualitative part of the research, an initial content analysis of the data gained through a document review of articles and theses conducted on TST studies, nationally and internationally, was carried out using a detailed version of the MaxQDA-10 program. Content analysis provides readers with a more comprehensible product by combining similar themes and codes from the data collected [Yıldırım and Şimşek, (2008), p.227]. A thematic analysis was then conducted to investigate the effect of TST on students’ academic achievement.

First, however, document analysis was used to collect the data. This method comprises an analysis of the written materials in respect of the targeted case or cases. This makes it possible to analyse documents in the related area that were generated over a specific period by several resources or over different periods [Yıldırım and Şimşek, (2008), pp.187–190]. In the research, three studies concerning TST were accessed through document analysis to obtain qualitative data. They comprise studies conducted between 2005 and 2016 years and are additional to those included in the meta-analysis. They were selected according to pre-determined criteria. These criteria are as follows:

a studies conducted between 2005 and 2016
b studies exploring participants’ perceptions regarding the effect of TST on academic achievement
c studies published in national and international journals. Based on these criteria, 12 studies were utilised.

These studies were then coded into a computer as TN: 276456, 276456 Numbered Thesis, UMI N: 3601749, Numbered Thesis, TFO10, TF 10th article. The articles for the thematic analysis were coded as follows: [(Aslan, 2012)TN:300430, (Bahçekapılı, 2011)TN:276456, (Bell, 2011)UMI N:3400289, (Brecht, 2010)UMI N:3403360, (Carr, 2012)UMI N:3553415, (Emmungil, 2009)TN:255089, (Li, 2014)TFO10, (Mosley, 2012)UMI N: 3549137, (Sandiford, 2013)UMI N: 360749, (Stokes, 2009)UMI N: 3421341, (Wright, 2013)UMI N:3605561, (Yaylak, 2010)TN:265164]. ‘TF’ code refers to the studies retrieved from the Taylor & Francis online database, while ‘UMI’ code refers to the international theses obtained from PQDT Global databases. To ensure consistency of the qualitative findings, the themes and coding were as complete and meaningful as possible. Illustrative quotations from participants were also used to enhance the reliability of the study. Coding of the qualitative data was carried out by two researchers. One of these was the researcher conducting the present study. The other coder was an academician who has had substantial experience implementing qualitative research in the educational sciences. The coders studied and coded the data
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independently. Following the coding process, common codes were selected to ensure reliability and validity. Additionally, agreement coefficient values (Cohen Kappa) were calculated to determine agreement among raters. For this calculation, the agreement coefficient values were interpreted as follows: .20 or < .20 = ‘poor’, .21–.40 = ‘fair’, .41–.60 = ‘moderate’, .61–.80 = ‘good’ and .81–1.00 = ‘very good’ [Viera and Garrett, (2005), p.362]. In terms of the themes used, the calculation for Kappa coefficient values was as follows: ‘Definitions with regard to the integration of technology into learning process (.709), insufficiencies/matters encountered in the integration of technology into learning process (.676), participants’ perceptions with regard to their experiences (.712), the process of cooperation providing participants with advantages (.656), students having advantages (.800) and teachers having advantages (.814)’. These values ranged from .676 to 1.00 and were all classified as ‘good/very good’.

4 Findings

In this section, the quantitative and qualitative findings regarding supported technology or a lack of technology in classroom settings are presented. Following the quantitative findings, a qualitative analysis of participants’ perceptions collected through document analysis is provided. By integrating the findings in this way, points of agreement/disagreement can be identified and revealed.

4.1 Quantitative results regarding TST

In the meta-analysis, 11 studies (seven articles, three Master’s theses and one PhD dissertation) met the criteria for selection and a determination of these studies was included in the current research. In Table 1, the frequency and percentage values for categorical independent variables of studies exploring the effect of TST on students’ academic achievement are displayed. From the grade level in Table 1, it is apparent most studies were conducted with students in upper secondary school (36.4%), followed by lower secondary school (27.3%) and then university (27.3%). In terms of the subject area, science (45.5%) is the area studied most often regarding publication type variable, most studies were published in articles (63.6%) and most of the rest came from masters’ theses (27.3%). In terms of sampling, 574 students (51.9%) were included in the experimental group and 533 students (48.1%) were included in the control group across the 11 studies.

Table 2 shows that the distribution of effect sizes based on the FEM was heterogeneous. In addition to the significance of the statistical Q-value, it can be asserted that changes in effect sizes may be greater due to sampling error (Lipsey and Wilson, 2001). Based on these results, teaching enhanced technology was compared to traditional teaching using the REM.

From this model, the results show that the standard error was 0.169, the upper limit of the confidence interval was 1.855, the lower limit 0.705 and the effect size was 1.280. The Z test score was 4.336 (p = 0.000). Based on Cohen’s classification (1992), the effect size value was found to be large. Given these findings, it can be concluded that teaching supported technology has a significant and positive impact on academic achievement.
Table 1  Frequency and percentage values for categorical independent variables of studies exploring the effect of TST on students’ academic achievement

<table>
<thead>
<tr>
<th>Variables (f)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade level</td>
<td></td>
</tr>
<tr>
<td>Lower secondary school</td>
<td>3</td>
</tr>
<tr>
<td>Upper secondary school</td>
<td>4</td>
</tr>
<tr>
<td>College</td>
<td>1</td>
</tr>
<tr>
<td>University</td>
<td>3</td>
</tr>
<tr>
<td>Subject area</td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>5</td>
</tr>
<tr>
<td>Technology</td>
<td>2</td>
</tr>
<tr>
<td>Foreign language</td>
<td>1</td>
</tr>
<tr>
<td>Engineering</td>
<td>1</td>
</tr>
<tr>
<td>History</td>
<td>1</td>
</tr>
<tr>
<td>Mathematics</td>
<td>1</td>
</tr>
<tr>
<td>Publication type</td>
<td></td>
</tr>
<tr>
<td>Article</td>
<td>7</td>
</tr>
<tr>
<td>Masters’ theses</td>
<td>3</td>
</tr>
<tr>
<td>PhD dissertation</td>
<td>1</td>
</tr>
<tr>
<td>Sampling</td>
<td></td>
</tr>
<tr>
<td>Students in experimental group</td>
<td>574</td>
</tr>
<tr>
<td>Students in control group</td>
<td>533</td>
</tr>
</tbody>
</table>

Table 2  The distribution of homogeneous values, average effect sizes, confidence intervals and the error protection for studies in the meta-analysis according to the effect models

<table>
<thead>
<tr>
<th>TST in teaching practices</th>
<th>Model type</th>
<th>N</th>
<th>Z</th>
<th>P</th>
<th>Q</th>
<th>ES</th>
<th>95% confidence intervals</th>
<th>NFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
<td>Upper limit</td>
</tr>
<tr>
<td>TST</td>
<td>FEM</td>
<td>11</td>
<td>14.138</td>
<td>0.000</td>
<td>176.790</td>
<td>0.932</td>
<td>0.802</td>
<td>1.065</td>
</tr>
<tr>
<td></td>
<td>REM</td>
<td>11</td>
<td>4.336</td>
<td>0.000</td>
<td>23.154</td>
<td>1.280</td>
<td>0.705</td>
<td>1.855</td>
</tr>
</tbody>
</table>

Note: NFS: fail-safe numbers R.’s. M: Rosenthal’s method

Publication bias in the meta-analysis means that a sufficient number of studies nullifying the effect sizes must be included in the meta-analysis. The number of studies included was given as a fail-safe number \(N_{FS}\) (Rosenthal, 1979). Using the Metawin program, the value for \(N_{FS}\) regarding the effect of TST on academic achievement was calculated as 964.7. When studies equal to this number were analysed, the effect of TST on academic achievement decreased to 0.001. When considering the 11 studies in the analysis, it is clear the figure of 964 studies is high. Therefore, it can be concluded that the results of the analysis are reliable.
4.2 Qualitative analysis of studies exploring TST

In the qualitative research, different aspects of participants’ perceptions of the effect of TST on academic achievement were examined. The relevant themes and codes are displayed in Figure 1.

**Figure 1** Participants’ perceptions regarding TST 1 (see online version for colours)

The overarching aim of this study was to identify teachers’ perceptions of TST. Based on these, a model depicting the different themes and codes was developed. Participants’ experiences regarding their ‘knowledge for technology’, ‘technological and pedagogical knowledge’, ‘technology content’ and ‘technological pedagogical content’ are presented in Figures 1 and 2. Regarding experiences of technological and pedagogical knowledge, several codes were formed such as ‘providing a variety of learning methods’, ‘presenting interesting materials’, ‘appealing to a number of senses’, ‘taking into account learners’ characteristics’, ‘developing experiences to make use of technology’, ‘enabling opportunity by doing’ and ‘learning and integrating technology with subject matter’. These codes were generated from the participants’ perceptions. For example, a quote taken from the PDTG46-99 coded study stated that, “learners’ learning level can be increased through technological opportunities enabling them to use a variety of learning methods and creating attractive learning environments.” Another example from the PDTG18-236 coded study states, “it is to develop learners’ active learning performance by integrating technology with the activities in classrooms.”
As shown in Figure 2, codes were formed for experiences of technological pedagogical content such as ‘enabling to restructure knowledge’, ‘making use of effective presentations and animations’, ‘assessing quality of education’, ‘assessing teachers’ role in learning process’, ‘access to more information by searching more’ and ‘acquiring concrete learning experiences’. Some of the codes were created by considering the statement “…more research can be conducted through technology. So, more information can be acquired.” in the PDTG7-168 coded study. Additionally, statements such as
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“...technology improves learners' learning performance. It also contributes to assessing and developing teachers’ performance with regard to their usage of technology” in the PDTG18-234 coded study were used to form related codes.

**Figure 3** Student and teachers’ perceptions concerning the process of cooperation in TST (see online version for colours)

In Figure 3, ‘the process of cooperation providing teachers with opportunities’ and ‘students and teachers’ perceptions of the related advantages’, are presented as different themes. Regarding the process of cooperation providing participants with opportunities, several codes were developed such as ‘blending different points of view’, ‘learning lessons from mistakes’, ‘giving a priority to originality’, ‘integrating the knowledge which has been acquired’ and ‘developing creative learning activities’. Conversely, regarding teachers’ perceptions of the advantages of the process of cooperation, the following codes were formulated; ‘saving time’, ‘increasing teachers’ productivity and efficiency’, ‘providing education specialists with a variety of alternatives’ and ‘increasing teachers’ skills to use technology’. These codes were developed from the statement “The advantages the internet gives to teachers are to enrich the learning process by providing a variety of alternatives and technology increases teachers’ teaching skills.” Derived from a PDTG46-64 coded study. Regarding the advantages of the process of cooperation for students, the codes formulated were; ‘providing opportunities which attract students’ attention’, ‘increasing internal motivation’, ‘developing creative skills and increasing students’ efficiency in data analysis’. The codes were generated from the statements, “technology is one of the most important resources to increase students’ learning performance...” in a PDTG46-99 coded study and “the usage of technology throughout the teaching process has sustained students’ motivation and makes it possible to reach
extensive information by utilising different mediums. Besides, it affects learning outputs positively by creating cooperative learning mediums” in a PDTG7-165 coded study.

**Figure 4** Issues arising in relation to TST (see online version for colours)

Thus, perceptions are provided of both disadvantages and advantages of the technologies used in education. Issues arising in relation to the use of TST can be categorised into three themes; undergraduate programs, context and students (as shown in Figure 4). Regarding issues relating to undergraduate programs, the following codes were formulated; ‘lack of learning experiences supported with technology’, ‘the insufficiency of the technology courses in education faculties’ and ‘just theoretical knowledge provided at undergraduate level’. Regarding issues relating to students’ use of TST, the following codes were formulated; ‘lack of knowledge for technology learning’, ‘students’ underestimation of the role of technology’ and ‘students not being competent to develop and find materials with regard to technology’. The codes were developed from a statement in a PDTG7-165 coded study that “the inadequate usage of technology in courses seen as a barrier for its effective usage can affect students’ performance negatively.” Regarding issues relating to the context of TST, several codes were derived such as; ‘lack of technical support’, ‘lack of computers in classrooms’, ‘overcrowded classrooms’ and ‘technology not being reliable and fallible’. Codes were constructed based on the following statement in a PDTG56-201 coded study, “lack of technical support, technology not being reliable and the incompatibility of the subjects which are appropriate for classroom culture with the presentations of these subjects through technology can appear as a handicap for the effective employment of technology in
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5 Discussion

The purpose of this meta-analytic study was to establish the effect of TST on students’ academic achievement. Additionally, an analysis of participants’ perceptions regarding the use of technology in teaching were conducted. In this study, control and experimental studies carried out nationally and internationally between 2005 and 2016 were explored using the CMA statistical program and the MetaWin package. In total, 11 quantitative studies and 12 qualitative studies were accessed and analysed. The effect of TST in an experimental group and the effect of traditional teaching on students’ academic achievement were statistically compared using a REM. The results show that the standard error was 0.169, the upper limit of the confidence interval was 1.855, the lower limit was 0.705 and the effect size was 1.280. This effect size was large according to Cohen’s (1992) classification. Thus, it can be concluded that TST positively influences academic achievement. The results of the meta-analysis agree with the results of previous research and internationally (Badeleh, 2011; Cantrell et al., 2007; Chauhan, 2017; Hwang and Chang, 2011; Hwang et al., 2013; Türkmen, 2009) albeit on different grades and courses. Moreover, no statistically significant differences were found between experimental and control groups regarding TST in research conducted nationally (Öner, 2009) and internationally (Shapley et al., 2011).

In addition to the meta-analysis, a thematic analysis was conducted to provide a more comprehensive understanding of TST and to triangulate with the quantitative findings. From this analysis, participants’ perceptions of their experiences in relation to their knowledge of technology, technological and pedagogical knowledge, technology content and technological pedagogical content indicate that the deployment of technology in education contributes to enhancing students’ learning, which corroborates the findings of the meta-analysis. Furthermore, emerging themes such as ‘the process of cooperation providing teachers with opportunities’ and ‘students and teachers’ perceptions of the related advantages’ affirms that technology has a considerable role to play in enhancing students’ learning strategies. It is clear both teachers and students have embraced the integration of technology into education to support the teaching and learning process. However, there are some issues arising from the application of TST in relation to undergraduate training programs, contextual factors and students. Firstly, undergraduate training programs have an important role to play in influencing how teachers will use technology in their classrooms (Tondeur et al., 2012). However, participants’ perceptions of the programs suggest the programs should be redesigned to enable teachers to become more competent users of technology in their classrooms. Aslan (2016), for example, suggests that, to be a competent user of technology, teachers should be exposed to vicarious learning through teacher training and professional development programs. To facilitate this, the synthesis of qualitative evidence model developed by Tondeur et al. (2012) could be applied in the programs. Furthermore, strategies such as using teacher educators as role models, reflecting on the role of technology in education, learning how to use technology by design, collaboration with peers, authentic technology experiences and providing continuous feedback can be used to address issues relating to
undergraduate training programs. Secondly, contextual matters in relation to TST are mainly concerned with the technology infrastructure in schools. To ensure the effective deployment of technology, teachers and students need to be able to access technology resources within schools. In this respect, a policy regarding technology infrastructure should be prepared, developed and implemented. Finally, regarding issues relating to students use of TST, it is clear students need to be competent in their use of technology. Furthermore, in terms of learning strategies, they should be given the opportunity to be exposed to augmented reality technologies and innovative technologies such as Web 2.0 so that they can benefit from these effectively and adequately. According to students’ perceptions, the effective and efficient use of technology depends on how innovatively it is used. In this respect, it can be argued that technological innovations should be accompanied by pedagogical innovations to ensure the effective employment of technology in education (Aslan, 2016).

In conclusion, the results of the meta-analysis show that TST is generally effective in enhancing students’ academic achievement. Thus, there is a positive relationship between the use of technology and students’ academic achievement. This finding was supported by the thematic analysis. Thus, it can be concluded that greater deployment of TST in the teaching process will make a more effective contribution to related courses and subjects. However, although several databases were reviewed to access studies on TST both nationally and internationally, the number of studies dealing with TST in relation to students’ academic achievement was limited. The findings should therefore be considered with caution and the following limitations borne in mind. Firstly, the number of studies in the meta-analysis was low due to the selection criteria and the data was derived from educational contexts that were different, namely secondary level, college and university level. Comparisons across different educational contexts are therefore problematic. Secondly, the research was mainly concerned with the effect of technology on learners’ academic achievement, that is, course grades rather than a specific ability to solve problems or recall facts. Therefore, in future studies, the sample size in each educational context should be increased to facilitate generalisability of the findings. Moreover, advanced statistical techniques such as multi-level analysis could be conducted to provide a more sophisticated analysis of the relationship between the effect of technology and learners’ achievement. Additionally, the specific use of Web 2.0 or augmented reality technologies rather than the general use of TST could be considered in relation to students’ achievement. In conjunction with this, the use of problem solving and/or fact recall in teaching and learning strategies could be explored in future research to develop road maps for researchers, educators and policy makers across the educational field.

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The references marked with an asterisk (*) are included in the meta-analysis.


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