TECHNOLOGICAL TEACHING MATERIAL IN SCIENCE CLASSES OF GREEK ELEMENTARY SCHOOLS

Konstantinos Karampelas and Michael Skoumios
University of the Aegean
Greece

Abstract

This paper aims to examine the integration of technologically oriented instructional material in elementary science in Greece. Such material is justified by research to assist science teaching. Whether teachers decide to use it depends on their knowledge and perceptions around teaching generally, the subject they teach and ICT. Based on these findings, this research study was designed aiming to show which materials teachers prefer to use in their work. This has not been thoroughly examined by research so far. Through observations and statistical analysis, the research draws conclusions about teachers' selections and suggests ideas for further projects.

Introduction

This research focuses on the field of technological instructional material in the subjects of science, in the context of Greek Education. It is necessary to look into the basic theoretical points of these basic and well-studied topics. The main concept that has to be negotiated and analyzed is the one of instructional material. There should be particular emphasis on the integration of instructional technology with regards to teaching science at the elementary school level. This can be done by reviewing how it is being used in tasks related to teaching or learning and what conclusions are drawn by research about it. Since the research focuses on the Elementary Educational system of Greece, these characteristics have to be considered as well (Cohen, Manion, and Morrison, 2011).

The term 'instructional material' refers to means of communication, dissemination, interaction and discussion that educators can use during teaching in order that learners benefit from the instruction. The use and effectiveness of instructional materials is based on the fact that communication among educators and learners is considered to be a very complex, multi-dimensional and bidirectional topic. The nature of this communication has a significant role in the effectiveness of teaching. Both educators and learners are expected to participate actively in the learning process so that they assist by sending and receiving messages and information, which will help the construction of knowledge, the skills to be developed and the attitudes to be adopted (Amadioha, 2009; Tyler, 2013).

Mostly instructional materials refer to tangible objects that are used either by the teacher or the learner. The interaction of the learner with the material can have a significant impact on the teaching outcome. There are various types of teaching materials, as well as various categories. A common categorization is among the conventional ones, such as the text-book, whiteboard, spreadsheet, and photocopies. There are however the technologically oriented ones, such as computers and

projectors, interactive whiteboards, audiovisual material, software and websites (Hora, Oleson & Ferrare, 2013; Hora, 2015).

Literature Review

The Science subject, according to the contemporary approach of the Next Generation Science Standards, aims to help learners to: develop and use models; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; construct explanations and design solutions; engage in argument from evidence; and obtain, evaluate and communicate information. These standards relate to topics such as data searching, analyzing, communicating, exchanging information and constructing knowledge (NGSS, 2013).

Bell, Davis & Linn (1995) support that ICT generally can assist science learning, which is often challenging for learners, as it is related to abstract ideas and concepts, sometimes outside their everyday experience. Integrating with ICT can help teachers give a deeper understanding of science as a dynamic field of on-going development and not a static body of knowledge. In addition to that, Linn, Mattuk, and Gerard (2016) state that ICT can assist inquiry learning, which is compatible to contemporary approaches to science teaching that emphasizes in the importance of inquiry, experimentation and investigation.

Mishra & Koehler (2016) stress the importance of the Technological Pedagogical Content Knowledge that teachers need to develop in order to include ICT in their teaching. This term encompasses knowledge about pedagogy, teaching, the subject matter, such as science and the potential of ICT applications, including technological teaching material. Teachers therefore need the appropriate background or training, in order to understand what types of technological material exist, which fit the content they have to teach, which can be used and how they can be adjusted to the context. Investigating integration of ICT in science teaching through the prism of technological pedagogical content knowledge expands in various dimensions. Three of them are: appreciating why to use ICT; understanding specific benefits of ICT application and technological instructional material; and knowing how to implement it in classroom (Bell at al, 1995; Linn et al, 2016).

With regards to the first dimension, Webb (2005) has pointed out four advantages. First, the extension of learners' experiences, information and evidence with science topics which they might negotiate. Second, through appropriate research approaches such as inquiry and experimentation, it is possible for learners to develop skills such as data collection and analysis, which can help them construct knowledge and solve problems. Third, similar tasks are expected to promote skills, such as designing solutions, research, communicating and critical thinking. Fourth, all these factors can assist healthy cognitive development and model designing.

With regards to the second dimension, there are benefits from technological instructional material in science teaching. Computers and projectors may help teachers present their material to learners. Interactive whiteboards give broad opportunities for interaction in the classroom and use of multimedia. Audiovisual material may be a good supplement to textbooks in explaining further the information and points negotiated. Education software, such as simulations, can offer

opportunities for learners and teachers to experiment even in contexts outside the learners' every day experience. Such contexts could be outer space, nuclear reactions and microworlds that would otherwise be difficult or even dangerous to use in classrooms (Law, 2009; Fokides & Mastrokoukou, 2018). Importantly, the internet can be used as a tool for gathering information and resources (Eady & Lockyer, 2013; Hora et al, 2013; Hora, 2015; Linn et al, 2016). Each of these advantages can be associated with different Science Standards (NGSS Lead States, 2013).

With regards to the third dimension, the teacher's decision to eventually use technological instructional material, in their actual work this is neither simple nor straightforward. This complexity usually derives from factors mediating in lesson planning (Uluyol & Şahin, 2016; Comi, Argentin, Gui, Origo & Pagani, 2017). Mueller Wood, Willoughby, Ross & Specht, (2008) when carrying out research in secondary education contexts, have tried to identify such factors. These were: teachers' comfort with computers, including ease and enthusiasm generally; teachers' use of computers in terms of frequency for any occasion, either personal or professional; teachers' training and knowledge on computers; teachers' attitudes towards computers and technology either as a learning or motivational tool; teachers' past experience of using their computers, including whether they have been helped or disappointed by it; teachers' general ideas about their teaching work and whether computer use is compatible to it; the general context where teachers work, including curricular demands, availability, legal issues or pupils attitudes; the actual topic or subject teachers aim to teach. These conditions are linked to the general context, where teachers work. Webb (2005) suggests that the interaction between the teacher factor, which encompasses beliefs, ideas, and pedagogical reasoning, and the wider context factor is what defines the affordances of ICT use in the classroom, along with the selection to use technologically oriented instructional material.

Therefore, the teacher's decision has to do with developing an appropriate relationship with ICT, relating its use to Science Standards that are to be achieved (NGSS Lead States, 2013), as well as linking to the general working conditions where teaching takes place (Law, 2009; Uluyol & Şahin, 2016; Fokides, 2017). In other words, the integration of ICT depends on how qualified teachers are with regards to pedagogy, technology, subject matter, and teaching practices (Linn et al., 2016). Limited is the research to identify exactly what types of instructional technology is actually being used in the classroom. In fact, this limited research focuses mostly on secondary or higher education. This actually stresses the rationale for particular research that focuses on elementary schools, in a specific educational context (Mueller et al, 2008; Uluyol & Şahin, 2016). Such research can give crucial evidence on the technological pedagogical content knowledge that teachers need to possess (Mishra & Koehler, 2016).

Methodology

This study took place in the context of the Greek Education System and was focused on three basic research questions, drawn from the literature.

Science in the Greek Education System

The Greek elementary school addresses pupils from the ages of 6 to 12 and is completed in six grades. Science topics exist in each one of the six grades. However, science is not a discrete subject in the first four years, where it is a major part of a subject called 'environmental study'. This includes geography and social themes. In the higher grades, the fifth and the sixth, science becomes a separate subject. It is taught for 3 sessions of 45 minutes per week. The topics taught in science are states of matter, mixtures and solutions, energy, heat, electricity and magnetism, mechanics, sound, light plants, animals and anatomy of the human body (Greek Ministry of Education, Research, and Religious Affairs [GMERRA], 2011).

The Greek Education system has been identified by the Organization for Economic Co-operation and Development [OECD] (2017) as a highly centralized system, especially at elementary and secondary education levels. This identification is based on the fact that many decisions about actual teaching are arranged at the level of the Greek Ministry of Education, restricting the initiatives and decision making of schools and teachers. In science, as with every subject in Greek primary and secondary education, a teaching package is distributed to teachers, who are expected to use it. This includes a teacher's book, with pre-designed lesson plans for the teacher as well as basic teaching instructions, the learners' book with subject matter, and the workbook which includes worksheets and experimental activities for learners to work through and construct knowledge. Unlike other subjects, where the basic axis of instruction is the pupils' book, in science, teachers are expected to use it mostly for reference. It is mainly the workbook that science instruction should be based on.

The elementary science curriculum suggests opportunities for teachers to use technological types of instructional technology in various activities (GMERRA, 2011). This can help stressing the potential of technological material (Tyler, 2013). The teachers' book also mentions indicative examples in various lesson plans. In fact, appropriate sites provide the teaching packages in digital form, where they include the texts and worksheets that the teachers can also use print (GMERRA, 2011).

The Research Questions

Having described the research context, in order to investigate the integration of technological instructional material in the science classroom, it is important to define relevant research questions. The definition and precision of the questions depends on the main theoretical points around the subject, as they are formed by the literature (Webb, 2005; Eady & Lockyer, 2013; Comi et al, 2017; Linn et al, 2016; Fokides, 2017). It is these questions, thereafter, that will assist in defining, according to their type and content, what method and approach of analysis fits for accurate and useful findings. Having in mind the above, the research questions are formed as follows:

1) What technological instructional types do teachers in elementary science classes use generally?
2) Is there differentiation among those types?
3) Is there differentiation between the types used in the fifth and the sixth grade?

These research questions can give insights into whether the teachers are familiar, appreciate and implement such instructional types in science class, which in turn can give information on their technological pedagogical content knowledge (Mishra & Koehler, 2016).

The Data Collected

Having stated the research questions, it is now important to plan the appropriate methodology to answer them. This includes sampling, planning data collection and data analysis (Cohen et al., 2011).

This research examined a sample of 80 elementary teachers, working in schools on the island of Rhodes. Half of them were in the fifth and the other half in the sixth grade. The data collection was completed by observing science lessons, as this specific data collection approach was found to be the most appropriate, bearing in mind the scope of the research (Cohen et al., 2011). Two science sessions of each teacher were watched. This means there were 80 sessions in the fifth and another 80 in the sixth grade. During the observations, any technological instructional means used was recorded, along with the amount of time of use, in minutes. This could be the interactive whiteboard, the internet, simulations, Web-sites and audiovisual material.

This recording was helped by a predesigned form. This form had divided the 45-minute session into nine intervals of five minutes. In the boxes of the form, which were corresponding to intervals, the types of instructional material used were noted and coded. It should be noted that it was possible for an interval to contain two different types of instructional material. For example, it is possible for a teacher to use within the same five-minute interval a website of information and simulations. It is also possible for a teacher to use no instructional material, either technological or conventional, within a specific interval (Eady & Lockyer, 2013; Hora et al, 2013; Hora, 2015). Since each session lasts for 45 minutes, which means nine intervals, the total number of intervals observed was 720 for each grade, or 1440 in total.

After the data collection was completed, analysis followed. Analysis was planned to be based on a statistical comparison between the recorded data of the fifth and the sixth-grade observations. This comparison was selected as appropriate to give insights into any common or differentiating points concerning the use of technological instructional materials by teachers. This analysis used Microsoft Excel and SPSS.

Firstly, the number of intervals that each type of instructional material was observed was noted in the Excel file. This led to the calculation of the sum, the frequencies, as well as the average of intervals in each grade. This helped further statistical analysis that was to follow. More specifically, for the first and the second research questions, the findings were based on descriptive statistics. For the third research question, the findings derived through calculation of the chi-square factor and standardized residuals. The standardized residuals serve as criteria to justify if there is any statistically significant differentiation, which is evident when they have a value equal to 2, or greater (Swift & Piff, 2014).

Data Analysis

With regards to the first research question, the completed observations completed showed that there are various types of technological instructional materials used in science classes, in both grades. As seen in the number of intervals and the average, which are shown in Table 1, teachers in the classes of the sample used computers, projectors, interactive whiteboards, audiovisual materials, software and the internet. This likely can be attributed to the fact that teachers are familiar with the use of such materials in their work and understand that their use has benefits for science classes. Moreover, the use may indicate a certain level of familiarization on behalf of teachers with technological means and their educational use (Mueller et al., 2008; Uluyol & Şahin, 2016). In combination with that, it may be due to the support of the wider context and the curricula, both at the level of ideas and theory as well as the level of facilitation in implementation in the actual teaching practice (Law, 2009; GMERRA, 2011; Uluyol & Şahin, 2016; Fokides, 2017).

Overall, the number of intervals where technological instructional types were used is a rather small portion of the total observed: the total number of intervals observed as a percentage of the total was only 28% in the fifth grade and 33% in the sixth. This might be attributed to the highly centralized character of the Greek Education system, which encourages teachers to abide by the distributed teaching package, the text book and teacher's book (OECD, 2017). The promotion of ICT through the teaching packages does not seem to encourage teachers to detach from conventional teaching means and instructional types (Law, 2009; Uluyol & Şahin, 2016).

Table 1

Numbers of intervals of use of technological instructional types and percentage of the total, N=720

Instructional Types	**5th grade, N=720**		**6th grade, N=720**	
	Intervals	**Percentage**	**Intervals**	**Percentage**
Computers and Projectors	92	12.78%	138	19.22%
Interactive whiteboard	94	13.00%	72	10.00%
Audiovisual material	10	1.44%	14	1.89%
Education software	4	0.56%	10	1.33%
Internet	4	0.56%	7	1.00%
TOTAL	204	28.33%	241	33.44%

With regards to the second research question, the numbers show that computers and projectors along with the interactive whiteboards are more used than other technological instructional materials. Comparatively, the first two types are observed to be used more frequently compared to the rest. This trend is rather obvious in both grades. It may be that the teachers tend to use the digital form of the textbook and the teaching package. This can be attributed to their dependence from it, due to the centralized character of schools (GMERRA, 2011; OECD, 2017).

This general trend might be attributed to the compatibility of the specific types of instructional technology to the teaching practices and approaches of the teachers. In other words, teachers might find these types easier to implement in their planning and

teaching instead of the others (Webb, 2005; Eady & Lockyer, 2013; Fokides & Mastrokoukou, 2018). Teachers may consider, for example, that the interactive whiteboard is more useful or easy to use in the classroom than education software, which they may think may divert slightly from the actual goals they want to achieve. This might indirectly relate to the structure of the lesson plans and their goals, as they are prepared and distributed centrally (GMERRA, 2011), addressing again the character and uniqueness of the specific context (OECD, 2017).

Lastly, in what concerns the third research question, as shown from the standardized residuals, there is no significant difference between the two grades. The value of the residuals, as demonstrated in Table 2, does not exceed the number 2, in any of the category variables, which would show significant difference statistically. Aside from that similarity is the greater picture of the values. The chi-square statistic is 12.1161. The p-value is 0.016508. Statistically, this result is significant at $p < 0.05$ (Swift & Pift, 2014). Overall, therefore, there seems to be a correlation between the two grades, which can be justified as they are consecutive years of the higher grades of elementary schools, guided by a similar curriculum. Any difference in the units taught might not be so great as to lead teachers to an alternate means of preferred technological instruction (Law, 2009; Uluyol & Şahin, 2016; Comi et al., 2017).

Table 2

Intervals of use of technological instructional types and standardized residuals

Instructional Types	**5th grade intervals**	**6th grade intervals**	**Standardized Residuals**
Computers and Projectors	92	138	-1.73
Interactive whiteboard	94	72	1.73
Audiovisual material	10	14	-0.25
Education software	4	10	-0.40
Internet	4	7	-0.28

Overall, the use of technological instructional material is not frequent. This applied to both the fifth and the sixth grades. Among the types used, the computers and the whiteboard seemed to be used more frequently than others. With regards to the technological pedagogical content knowledge, the findings show that probably these types were considered to be more compatible to the teachers' practices, ideas and conditions of work (Webb, 2005; GMERRA, 2011; Eady & Lockyer, 2013; Linn et al., 2016). There may be an issue of availability (Fokides, 2017). Teachers may lack appropriate background and professional development (Mishra & Koehler, 2016), or the policy, regarding curricula implementation is not so effective (Tyler, 2013).

Conclusions

This research aimed to give insights to the use of technologically oriented instructional types in the science classes in the higher grades of Greek Elementary Schools. Computers, projectors, interactive whiteboards, audiovisual material,

software and the Internet are generally justified for science teaching (Amadioha, 2009; Eady & Lockyer, 2013; Linn et al, 2016). This applies generally to each subject and specifically to science class, where ICT oriented instructional types are found in research to promote knowledge acquisition, skill development and attitude adoption, which are important to science teaching (Law, 2009; Uluyol & Şahin, 2016).

Research has drawn a list of factors that influence the teachers' decision whether or not to use these types in teaching. The integration of ICT in science teaching depends on and reflects teachers' technological pedagogical content knowledge, which relates to teachers' background in pedagogy, ICT familiarization, and knowledge of the subject taught (Mishra & Koehler, 2016). This generally influences teachers' attitudes and ideas, and the way the manage or interact with the wider school and educational context (Eady & Lockyer, 2013; Comi et al., 2017; Fokides & Mastrokoukou, 2018). Limited though is the research that has identified how frequently teachers use these types of technological materials in teaching. This is the rationale of this study.

Within this research, elementary school teachers were observed, while teaching science. During the observations, the frequency that technologically oriented instructional materials used, was recorded and analyzed. Analysis was of a based on descriptive and inferential statistics (Cohen et al., 2011; Swift & Pift, 2014). The main findings were that overall, there was limited use of these types. These data indicate that there is an existent yet rather restricted integration of ICT in the science subject on behalf of the teachers. This integration might call for further development of teachers' ability to involve technological material in the science classroom by relating it to the standards (NGSS, 2013). In other words, teachers need to be assisted to enhance their knowledge and skills in that matter (Linn et al., 2016). Any attention to the teachers' background in pedagogy, ICT, science teaching and integration, which are dimensions of their technological pedagogical content knowledge, should focus in that direction (Mishra & Koehler, 2016).

Before generalizing these conclusions, though, it is important to mention that this research focused on a specific sample of a certain area of schools in Greece. It would be interesting to benchmark these findings with other projects with greater samples, as well as with the opinions of teachers (Cohen et al., 2011).

References

Amadioha, S. (2009). The Importance of Instructional Materials in our Schools an Overview. *New Era Research Journal of Human, Educational and Sustainable Development*, *2*, 61-63.

Bell, P., Davis, E. A., & Linn, M. C. (1995). *The knowledge integration environment. In The first international conference on Computer support for collaborative learning - CSCL '95*. Association for Computational Linguistics. https://doi.org/10.3115/222020.222043

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London; New York: Routledge.

Comi, S. L., Argentin, G., Gui, M., Origo, F., & Pagani, L. (2017). Is it the way they use it? Teachers, ICT and student achievement. *Economics of Education Review*, *56*, 24–39. https://doi.org/10.1016/j.econedurev.2016.11.007

Eady, M., & Lockyer, L. (2013). Tools for learning: technology and teaching strategies. In P. Hudson (Ed.), *Learning to teach in the primary school* (pp. 71-89). Cambridge: Cambridge University Press.

Fokides, E. (2017). Examining Greek pre-service teachers' intentions to use computers as in-service teachers. *Contemporary Educational Technology*. *8*. 56-75.

Fokides, E., & Mastrokoukou, A. (2018). Results from a Study for Teaching Human Body Systems to Primary School Students Using Tablets. *Contemporary Educational Technology*, 154–170. https://doi.org/10.30935/cet.414808

Hora, M. T. (2015). Toward a descriptive science of teaching: How the TDOP illuminates the multidimensional nature of active learning in postsecondary classrooms. *Science Education*, 99(5), 783-818.

Hora, M. T., Oleson, A., & Ferrare, J. J. (2013). *Teaching dimensions observation protocol (TDOP) user's manual*. Madison: Wisconsin Center for Education Research.

Law, N. (2009). Mathematics and science teachers' pedagogical orientations and their use of ICT in teaching. *Education and Information Technologies*, 14(4), 309-323.

Linn, M. C., Matuk, C., & Gerard, L., (2016). Technology as Inquiry Teaching Partner. *Journal of Science Teacher Education*, 27(1), 1–9. https://doi.org/10.1007/s10972-016-9457-4

Greek Ministry of Education, Research, and Religious Affairs [GMERRA] (2011). *Elementary School Curricula for 'New School'*. Retrieved from: http://ebooks.edu.gr/new/ps.php

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

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers & Education*, 51(4), 1523-1537.

NGSS. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. https://www.nextgenscience.org/trademark-and-copyright##4.0

Organisation for Economic Co-operation and Development [OECD]. (2017). *Education for a bright future in Greece, reviews of national policies for education*. http://dx.doi.org/10.1787/9789264298750-en

Swift, L. & Piff, T., (2014). *Quantitative Methods for Business, Management & Finance*. (4th ed.) Palgrave. Macmillan

Tyler, R. W. (2013). Basic principles of curriculum and instruction. In *Curriculum Studies Reader E2* (pp. 60-68). Routledge.

Uluyol, Ç., & Şahin, S. (2016). Elementary school teachers' ICT use in the classroom and their motivators for using ICT. *British Journal of Educational Technology*, 47(1), 65-75.

Webb, M. E. (2005). Affordances of ICT in science learning: implications for an integrated pedagogy. *International Journal of Science Education*, 27(6), 705–735. https://doi.org/10.1080/09500690500038520

Author Details

Konstantinos Karampelas
kkarampelas@aegean.gr

Michael Skoumios
skoumios@rhodes.aegean.gr