The Evolution of Educational Technology Based on a Bibliometric Study

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Introduction

During the past years, the increased interest for applying technology to improve learning and teaching (Spector, 2012) has led to the evolution of this discipline from educational technology (ET) defined as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Januszewski & Molenda, 2008) to technology-enhanced learning (TeL) referring to a transformative movement in learning and teaching that exploits technological advances for offering learning experiences not possible to be organized in current formal educational settings (Haythornthwaite & Andrews, 2011). Educational technology and TeL are now mature interdisciplinary research areas, and there are already literature studies aiming at the study of scientific communities, the identification and evolution of salient topics, and the emergence of the trends in the field (Cho, Park, Jo, & Suh, 2013; Kinshuk, Huang, Sampson, & Chen, 2013; Masood, 2004; Pham, Derntl, & Klamma, 2012). Such studies are important since they can provide insights into the

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development of a particular research area. Typically, social network analysis and bibliometric approaches using co-word, performance analysis, and science mapping have been exploited for this purpose (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011; Masood, 2004; Muñoz-Leiva, Sánchez-Fernández, Liébana-Cabanillas, & Martínez-Fiestas, 2013).

In educational technology and TeL, there are some efforts to analyze research trends and scientific communities using as sources articles published in journals (Cho et al., 2013; Klein, 1997; LeBaron & McDonough, 2009; Masood, 2004). On the other hand, Randolph, Julnes, Bednarik, and Sutinen have indicated that "there were no practically or statistically significant differences between the articles published in journals and those published in conference proceedings on any of the indicators of methodological quality" (2007). As a result, there have been similar studies where the sources were articles published in international conference such as the IEEE International Conference on Advanced Learning Technologies (ICALT) (Pham et al., 2012; Randolph et al., 2005) and the Artificial Intelligence in Education conference organized by the International Artificial Intelligence in Education (AIED) Society (Rourke, Anerson, Garrison, & Archer, 2001).

In this work, we aim to investigate the evolution of the educational technology field in a European Union member state, namely, Greece, through the analysis of the category of targeted research outcomes and the key topics of interest that have been emerged in all papers presented at the main national scientific conference of this field between 2000 and 2012. More specifically, we analyzed papers presented in the biannual conference of the Hellenic Scientific Association for ICT in Education, a nonprofit scientific association founded in 2000 with the aim to promote research and development in the field of educational technology. Through this analysis, we aim to identify trends between three different categories of targeted research outcomes (theory, technology, practice) and the evolution of different key topics of interest over a period of 12 years. We then discuss these trends in relation to educational technology policies and programs that have stimulated both research and development activities as well as mainstreaming activities aiming to widespread adoption of educational technologies in school education.

Method

Sample

The sample of this study consists of the population, namely, all the articles published in the proceedings of all seven biannual national conferences organized by the Hellenic Scientific Association for ICT in Education between 2000 and 2012. The association is the only scientific, on behalf of membership criteria, body in the field in Greece and represents almost the entire research community in Greece, and its conferences are the biggest in Greece. Thus, it can be considered that a

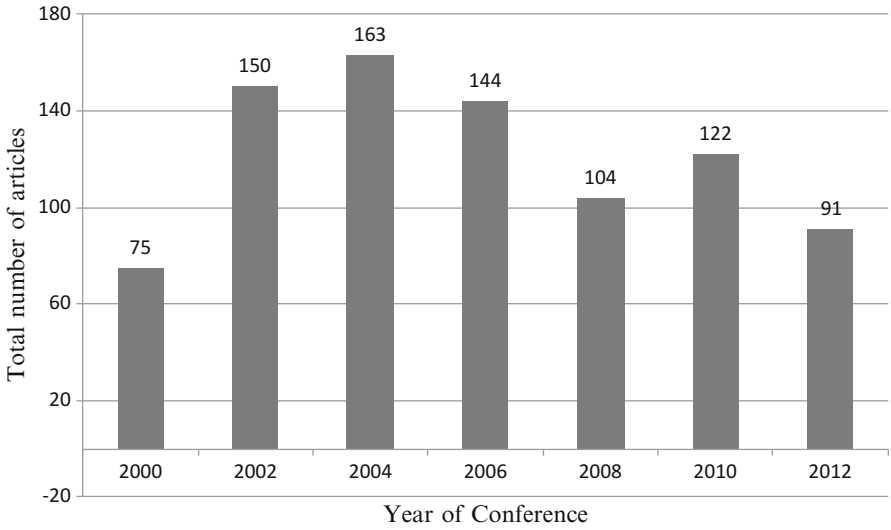

Fig. 1 Population of articles per biannual conference (2000–2012)

bibliometric analysis based on the association's proceedings covers the Greek community of ICT in education in Greece. The number of articles presented and published in both printed and electronic form is 849 which constitutes a significant number of articles from which we can extract meaningful conclusions. Figure 1 shows the distribution of all articles in the seven biannual conferences from 2000 to 2012. It can be seen that there is a reasonably balanced distribution with peaks during 2002–2006 due to the implementation of a large-scale public-funded program for introducing ICT in school education which stimulated interest from both educational practitioners and researchers.

Bibliometric Approach

For the purposes of the present study, the co-word analysis, as a powerful quantitative content analysis technique "in mapping the strength of association between information items in textual data" (Cobo et al., 2011), is applied. Moreover, co-word analysis is used for temporal analysis and "develops a performance analysis of specific themes using a series of basic bibliometric indicators" (Muñoz-Leiva et al., 2013).

The key topics of interest are formed by studying the common keywords from the corpus of the articles. The keywords used are retrieved from the conference index, author's keywords, and their combinations. Moreover, two different coders studied a specific number of articles and found common keywords at a level of 80 % that is usually characterized as standard (Rourke et al., 2001). Based on the common keywords, clusters of keywords are formed, thus creating the key topics of interest.

Results

First, we have identified three different categories of targeted research outcomes, namely, theory, technology, and practice. The first category concerns with theoretical issues of educational technology such as "pedagogy in TeL" and "learning design: theoretical aspects." Thus, we refer to this category as "theory." The second category concerns with a variety of learning technologies, from "authoring tools for educational content and learning designs" and "course management systems" to "wireless, mobile, and ubiquitous technologies" and "Web 2.0 and social computing technologies," and involves articles that emphasize on learning systems based on these technologies. We refer to this category as "technology." The third category concerns with those topics of interest that relate to the practical pedagogical exploitation of ICT in formal and informal learning settings, including ICT in teaching various subject domains, and other implementation issues of ICT in education. Thus, we refer to this category as "practice."

Table 1 presents the categories of targeted research outcomes (level 1) and their corresponding key topics of interest per category of research that have arisen from the co-word analysis (level 2), together with their frequencies (%) and absolute frequencies for the entire 12-year period. It can be noticed that the balance between the three different categories of targeted research (theory—5.18 %, technology—10.95 %, and practice—83.86 %) indicates that the vast majority of conducted research concerns with the practical use of existing theories and technologies in school education.

Figure 2 illustrates how these trends are evolved over time during the 12-year period. It can be noticed that basic research ("theory") tends to be reduced and applied technological research ("technology") has a constant increase (mainly due to the continuing development of new technologies), but still the core bulk of research concerns "practice."

This is consistent with our hypothesis that the community considers that the field of educational technology has matured enough to mainly concern mainstreaming (that is, large-scale implementation of technology-supported educational innovations in formal setting, like schools), rather than basic research or even applied technological research. This is consistent with current European Union policies and trends in TeL.

Figures 3, 4, and 5 illustrate the time evolution of key topics of interest in each category of targeted research outcomes during the 12-year period.

From Fig. 3 it can be noticed that in category "theory" the main topics of interest have been "learning design: theoretical aspects" and "pedagogy in TeL," whereas there are some sporadic contribution in "learning theories in TeL" and "e-assessment: theory and methods." Even so, the topic with a consistent interest over time has been the "pedagogy in TeL," which is reasonable since the implementation of large-scale ICT in school education programs stimulates interest in basic research related with the rethinking of pedagogy in TeL.

Table 1 Key topics of interest in national conferences

Level 1: Category of targeted research outcomes	Level 2: Key topics of interest	Frequencies (%) of level 1 categories over 2000–2012	Absolute frequencies of level 1 categories over 2000–2012 ($N=849$)	Frequencies (%) of level 2 topics over 2000–2012	Absolute frequencies of level 2 topics over 2000–2012 ($N=849$)
Theory	Pedagogy in technology-enhanced learning	5.18	44	2.00	17
	Learning theories in technology -enhanced learning			0.35	3
	Learning design: Theoretical aspects			2.71	23
	e-Assessment: Theory and methods			0.12	1
Technology	Authoring tools (educational content, learning design)	10.95	93	2.47	21
	Course management systems			0.59	5
	Virtual environments and worlds			2.00	17
	Digital games			0.24	2
	Educational robotics			0.24	2
	Wireless, mobile, and ubiquitous technologies for learning			0.35	3
	Collaborative technologies			2.00	17
	e-Assessment tools			1.77	15
	Tools for education of people with disabilities			0.47	4
	Web 2.0 and social computing in education			0.24	2
	Hypermedia and multimedia			0.59	5

(continued)

Table 1 (continued)

Level 1: Category of targeted research outcomes	Level 2: Key topics of interest	Frequencies (%) of level 1 categories over 2000–2012	Absolute frequencies of level 1 categories over 2000–2012 ($N=849$)	Frequencies (%) of level 2 topics over 2000–2012	Absolute frequencies of level 2 topics over 2000–2012 ($N=849$)
Practice	ICT in science education	83.86	712	13.19	112
	ICT in mathematics education			7.54	64
	ICT in language and literature education			7.89	67
	ICT in history education			6.01	51
	ICT in foreign language education			3.42	29
	ICT in computer science education			10.13	86
	e-Assessment: Implementation issues			2.71	23
	Distance learning: Implementation issues			11.90	101
	Digital literacy			8.13	69
	Continuing professional development programs—teachers' training			8.01	68
	Educational management			2.00	17
	Educational policy			1.18	10
	ICT in education of people with disabilities			1.77	15

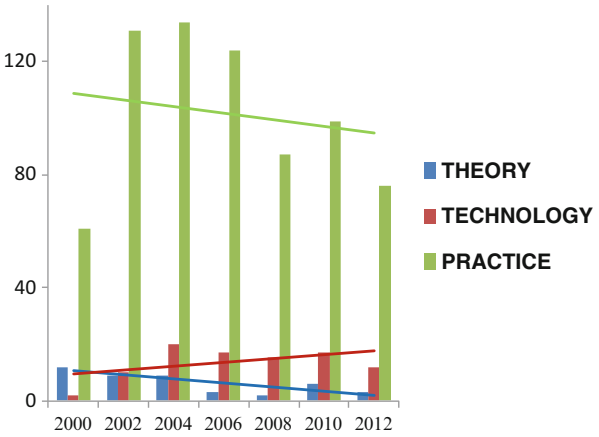

Fig. 2 Categories of targeted research outcomes over time

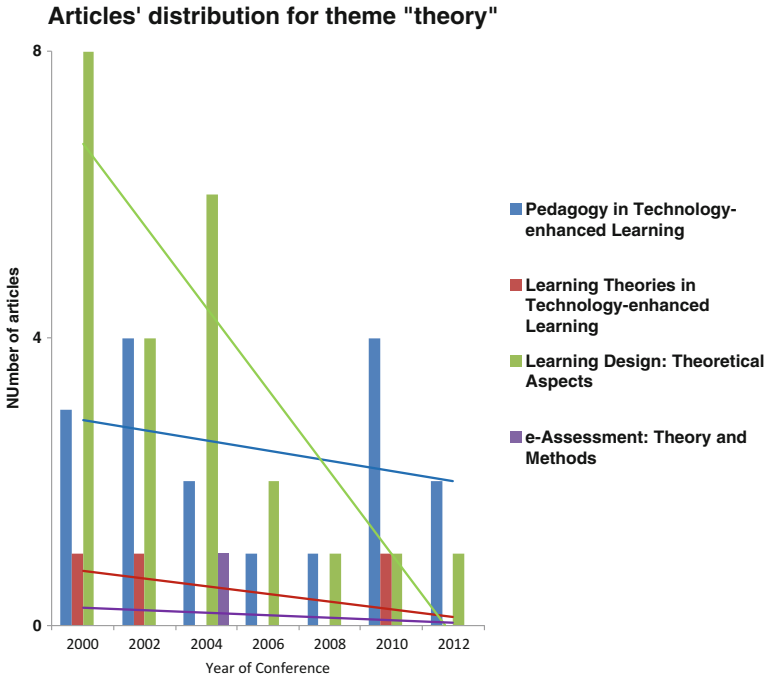

Fig. 3 Time evolution of key topics of interest in "theory"

From Fig. 4 it can be noticed that in category "technology" the main topics of interest have been "authoring tools for educational content and learning designs," "virtual environment and worlds," "collaborative technologies," and "e-assessment tools." It is also interesting to notice that there is a consistent interest on these topics over time. This is reasonable since authoring tools and e-assessment tools are

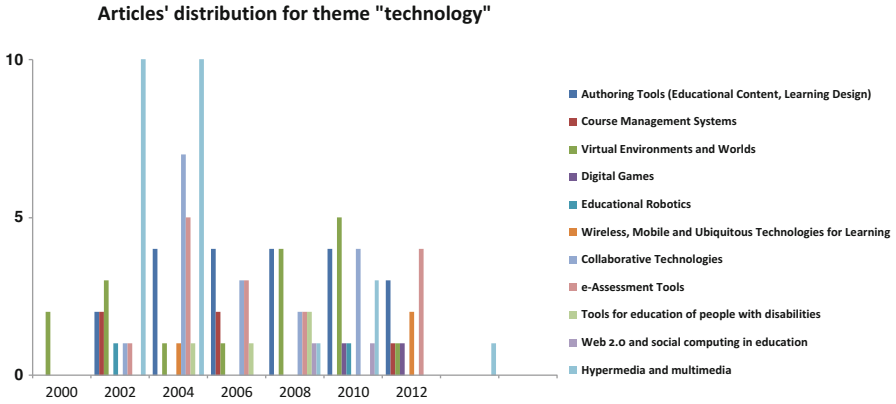

Fig. 4 Time evolution of key topics of interest in "technology"

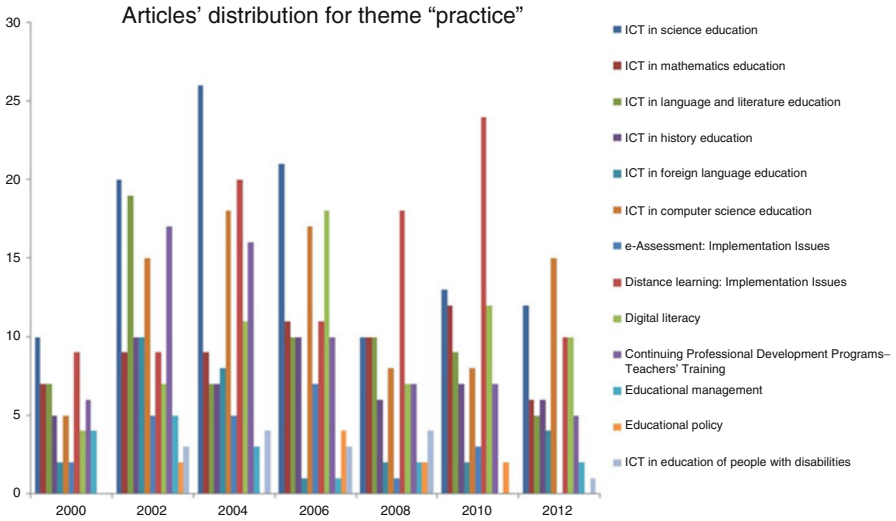

Fig. 5 Time evolution of key topics of interest in "practice"

directly useful in the implementation of large-scale ICT in school education programs, whereas collaborative technologies are attracting practical interest since collaborative learning aspects are considered a major educational innovation that can be supported by technology. On the other hand, applied technological research on topics such as digital games and educational robotics, as well as wireless, mobile, and ubiquitous technologies, appears not to be supported by the Greek research community, mainly due to the lack of national industry that develops such technologies.

From Fig. 5 it can be noticed that in category "practice" the main topics of interest have been "ICT in science education," "ICT in computer science education," and "distance learning: implementation issues." This is reasonable because science,

technology, engineering, and mathematics (STEM) are the key school curriculum subject domain topics that can benefit the most from innovative technology-supported teaching and learning strategies (Rocard et al., 2007). This is consistent with finding in other member states of the European Union and all over the world (Rocard et al., 2007).

Conclusions

Educational technology and TeL are now mature interdisciplinary research areas, and there are already literature studies aiming at the study of scientific communities, the identification and evolution of salient topics, and the emergence of the trends in the field. Such studies are important since they can provide insights into the development of a particular research area.

In this work, we investigated the evolution of the educational technology field in a European Union member state, namely, Greece, through the analysis of trends between three different categories of targeted research outcomes (theory, technology, practice) and the corresponding key topics of interest that have been emerged in all 849 papers presented at the main national scientific conference of this field between 2000 and 2012.

Some interesting conclusions can be drawn for the discussion of the obtained results. It appears that the educational technology community, at least in Greece, considers that the field has matured enough to mainly concern mainstreaming (that is, large-scale implementation of technology-supported educational innovations in formal setting, like schools), rather than basic research or even applied technological research. This can be a misleading route which can result to disappointments, since using existing technologies, mainly developed out of the context of learning and education, simply used as a facilitator for implementing incremental innovations in school education has potential risks of failure. In our view, the truly transformative value of educational technologies in formal and informal learning requires disruptive innovations that question the why–what–how–where of learning and teaching in the digital era. To this end, basic and applied technological and pedagogical interdisciplinary research is needed more than any other time in the past.

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