Received April 13, 2018, accepted June 11, 2018, date of publication June 29, 2018, date of current version July 25, 2018.

Digital Object Identifier 10.1109/ACCESS.2018.2851748

Analysis of New Technology Trends in Education: 2010-2015

SERGIO MARTIN, (Senior Member, IEEE), ESTHER LÓPEZ-MARTÍN, AFRICA LOPEZ-REY, JOAQUÍN CUBILLO, ALEXIS MORENO-PULIDO, AND MANUEL CASTRO, (Fellow, IEEE)
Universidad Nacional de Educación a Distancia, 28040 Madrid, Spain

Corresponding author: Esther López-Martín (estherlopez@edu.uned.es)

This work was supported in part by the UNED Industrial School Project under Grants 2018-IEQ-15 and 2018-IEQ18, in part by the eMadrid Project under Grant S2013/ICE-2715, in part by IoE-EQ under Grant 2017-1-IT01-KA202-006251, and in part by IoT4SMEs under Grant 016-1-IT01-KA202-005561.

ABSTRACT This paper analyzes the evolution of technology trends in education from 2010 to 2015, using as input the predictions made in the Horizon Reports on Higher Education, published yearly since 2004. Each edition attempts to forecast the most promising technologies likely to impact on education along three horizons: the short term (the year of the report), the midterm (the following two years), and the long term (the following four years). This paper applies social analysis, based on Google Trends, and bibliometric analysis, with data from Google Scholar and Web of Science, to these predictions in order to discover which technologies were successful and really impacted mainstream education, and which ones failed to have the predicted impact and why. This paper offers guidelines that may be helpful to those seeking to invest in new research areas.

INDEX TERMS Evaluation methodologies, postsecondary education, media in education, educational technology, technology forecasting, computer aided instruction, mobile learning.

I. INTRODUCTION

The birth of new ideas and technologies transforms the way in which humans communicate and relate to the environment. Their daily actions are conditioned by the connectivity between humans and the data around them. Computers or smartphones, intelligent objects such as quick response codes, radiofrequency labels and biometric identification are all technologies applied to life.

The evolution of all technologies implies their assimilation and knowledge. They start by being used in a specific area by experts to end up being used by anyone with basic knowledge. The technology evolves transforming its complex and remote appearance into an available natural experience for the user.

Thus, technologies already present, which originally arose in specific areas such as aerospace, military or medicine, now receive new applications, which render them suitable for marketing, trade or education. Thanks to the evolution of these technologies, most users of mobile devices have motion sensors, accelerometers, GPS, high-resolution cameras and communication systems such as Bluetooth or NFC. Many are also starting to use new technological tools like 3D printing, augmented reality, gestural control, etc.

These emerging technologies have attracted the interest of researchers, who seek new ways to apply them in order to promote, improve and rethink learning [1]–[8], and to predict which technologies will impact the field of education.

Regarding the latter, there are a number of references and bibliographic sources that make predictions about which technologies will be the most relevant in future education, such as the Institute for Prospective Technological Studies Reports (one of the seven scientific institutes of the European Commission's Joint Research Centre [http://ipts.jrc.ec.europa.eu/publications/index.cfm]) or the Horizon Reports (HRs) (www.nmc.org/horizon), developed by the New Media Consortium (www.NMC.org) and the EDUCAUSE Learning Initiative (ELI) (, as well as conferences on technology in education, such as Frontiers in Education (http://fie-conference.org), the IEEE EDUCON Engineering Conference (www.educon-conference.org), the AACE e-Learn Conference (www.aace.org/conf/elearn), the ISTE Conference (www.iste.org), and the TIE New Frontiers (tiecolorado.org/conference/).

These documents aim to identify the technological trends that impact education and constitute a reference and technology planning guide to enable educators, higher education leaders, policymakers, etc., to make responsible and informed decisions. However, in spite of the informative value of these publications, not all emerging technologies impact education in the same way. For this reason, it is important to determine the individual success of each one.

The aim of this work is to assess the predictions made by the Horizon Reports on Higher Education published between 2010-2015 (i.e. from six Horizon Reports), attending to the social interest and scientific impact of technologies. Every year since 2004, these reports have predicted the impact of emergent technologies on education across the world, using three temporal horizons: the year of the report (short-term predictions), the next two years (mid-term predictions), and the four years following the report (long-term predictions). According to the figures provided by the Horizon Report Project, these reports receive over 500,000 downloads a year and have an estimated readership of about 1 million in 75 countries.

The methodological approach adopted in this work has a dual perspective. On the one hand, social interest has been studied using the Relative Search Volume (RSV) provided by Google Trends (GT). This measure informs about the proportion of searches for a specific term relative to all the searches made in Google over a specific time.

Although this tool has only started to be used in this educational area (proved by the fact that the search for "Google Trends" in the database of the Education Resource Information Center -ERIC- only recovered 7 bibliographic records), its potential to measure the interest in specific terms has been demonstrated in several studies mainly conducted in the field of medicine [9]–[14] and economy [15]–[21].

Hence, searches in PubMed (a database developed and maintained by the National Center for Biotechnology Information [NCBI] at the National Library of Medicine [NLM]) and in IDEAS (the largest bibliographic database dedicated to Economics, based on Research Papers in Economics [RePEc]) yield results of 229 and 244 bibliographic records, respectively (consulted in April 2018).

On the other hand, in relation to the scientific impact, bibliometric studies have been widely used to analyze trends and to identify emerging scientific areas [22]–[27]. In our case, scientific impact was assessed by means of a bibliometric analysis, based on the one used by Martin *et al.* [28] for HRs (2004-2010). In any case, it differs from the previous one in that it includes the prestigious and selective databases of the Web of Science (WoS) together with Google Scholar (GS).

This work can be seen as a tool for researchers in education technologies, given that it helps to identify if the information on these reports has any correlation with the evolution of these indicators. As such, it may prove useful to researchers when deciding where to focus their research efforts.

The paper is structured into five main parts: an introduction; a methodology section, which lists bibliographic sources and describes the stages of the study; a results section, which includes a compilation of the data obtained from GT, GS and WoS, and analysis of technology flows and evolution; a discussion section, which contains critical analysis of the results; and a conclusions section, which provides findings, highlights, constraints, benefits and direction for future research.

II. METHODOLOGY

The procedure followed to achieve the proposed objective can be divided into four different steps.

A. IDENTIFICATION OF THE KEY TECHNOLOGIES

As mentioned previously, every year the HRs forecast two educational technologies to be implemented in higher education in the short term (one year or less), another two for the medium-term (for two to three years) and, finally, two long term ones (for four to five years). Assuming that there will be less error in short term ones, here we have contemplated the technologies to be implemented the year after the report is published.

B. DETERMINATION OF THE STUDY PERIOD

Firstly, 12 educational technologies identified in the six reports published between 2010 and 2015 (Table 1) were selected. Table 1 also shows the terms associated with the technologies. The selection of the terms was made by authors, based on the technologies identified in the HRs. Then, a group of eight experts in educational technologies assessed the relevance of considering these related terms and proposed other alternatives that should be taken into account.

Secondly, for each one evolution of the social interest and scientific impact in the two years immediately following publication of each report was analyzed. The study period, therefore, extended from 1st January 2008 (two years prior to publication of the HR2010) until 31th December 2017 (approximately two years after publication of the HR2015).

C. ASSESSMENT OF THE SOCIAL INTEREST

This interest was measured by means of the Relative Search Volume (RSV) provided by Google Trends. Searches with this instrument were carried out on March 26, 2018, and the following search criteria were used for each of the 12 technologies: a) time limit: two years before and after publication of the term in the HR (for example, for a term published in HR 2010, the interval from 1st January 2008 until the 31st December 2012 was considered); b) geographical limit: no geographical limitation was defined; c) search categories: the search is limited to the categories "Education" and "Colleges & Universities." Using these categories, two measures of interest of these terms were obtained worldwide: in the context of education in general, and particularly in the context of higher education.

D. DETERMINATION OF THE SCIENTIFIC IMPACT

Scientific impact was assessed by analyzing the number of scientific studies published on the aforementioned

TABLE 1. Educational technologies forecast for the short term in the HRs 2010-2015.

Keywords	HRs Edition	Related terms*
Mobile computing	2010	mobiles, mobile devices, laptops, mobile phones, smartphones, tablets**
Open content	2010	open education, open educational resources, OER, open courseware
Electronic books	2011	e-books, ebooks, digital books, digital textbooks**
Mobiles	2011	mobile computing, mobile devices, laptops, mobile phones, smartphones, tablets**
Mobile apps	2012	mobile applications, mobile device applications, apps
Tablet computing	2012	tablets, tablet computers, iPads
Massively open online courses	2013	Massively open online courses, MOOCs
Tablet computing	2013	tablets, tablet computers, iPads
Flipped classroom	2014	flipped, flipped learning, flipped education, flipped instruction, inverted classroom
Learning analytics	2014	-
Bring your own device	2015	BYOD
Flipped classroom	2015	flipped, flipped learning, flipped education, flipped instruction, inverted classroom

* Singular and plural forms of the terms were introduced in the information retrieval equations.

** Related terms were adjusted to the maximum number of characters allowed in GT and GS.

technologies in GS and in WoS. With Google Scholar we could examine a number of multidisciplinary academic repositories, such as "Springer," "IEEExplorer," "Wiley Online Library," "JSTOR," "ERIC," and Questia – Trusted On-line Research (www.questia.com). It also enabled us to access the libraries of several universities around the world, and even academic social networks such as Mendeley (mendeley.com). In contrast with the globality of GS, the search in WoS was also chosen, namely the prestigious and selective databases SCI, SSCI and A&HCI. In both cases, the following search criteria were used: a) time limit: two years before and after publication of each technology in HR to obtain the history of publications for each keyword; b) publication field: the search was narrowed down to education-related publications, by selecting only publications with the keywords "learning" or "education" in the title in GS and in the topic in WoS (topic searches include the following fields within a record: title, abstract and keywords). Each year was multiplied by the Weighting Factor (WF) proposed by Martin *et al.* [28]. For example, if the interval of years studied for a technology published in HR 2010 extended from 2008 until 2012, the publications in each of these years were weighted by the following WF:

$$WF_i = \frac{\bar{p}}{p_i} = \frac{\frac{1}{2}\sum_{i=2008}^{2012} p_i}{p_i} \tag{1}$$

$\bar{p}$ = mean number of publications from 2008 to 2012
p_i = number of publications in the year i
i = {2008, 2009,. . ., 2012}
N = Total number of years

E. ANALYSIS OF RESULTS

Firstly, the evolution of the four indicators analyzed for the 12 technologies selected were represented graphically: search volume in the categories "education" and "colleges & universities" of GT (social interest), and number of publications in GS and WoS (scientific impact). The next step was to determine whether the predictions made for the HRs correlated with social interest and scientific impact, by means of the following procedure:

a. Relation to social interest. The difference was calculated between the social interest of the terms analyzed in the year of publication of the HR report, and the average interest over the two years prior to (2) and following (3) this year of reference.

$$X_t - \frac{X_{t-1} + X_{t-2}}{2} \tag{2}$$

$$X_t - \frac{X_{t+1} + X_{t+2}}{2} \tag{3}$$

b. Impact on scientific interest. In this stage, it is important to notice that while the results of GT may help to predict the present (nowcasting), the documents published one year were the result of the research work in the previous year because of the publishing delay. This aspect was taken into account when comparing the HR predictions with their effect on publications and, consequently, the difference between the volume of studies published up until the study year and the number of studies published one year (4) and two years after (5) publication of the report.

$$X_{t+1} - \frac{X_t + X_{t-1} + X_{t-2}}{3} \tag{4}$$

$$X_{t+2} - \frac{X_t + X_{t-1} + X_{t-2}}{3} \tag{5}$$

III. RESULTS

Figure 1 shows the evolution of the social interest and scientific impact of the educational technologies, which, according to HR2010, would impact the field of higher education in one year or less after publishing the report. The results show that the search volume in Google of the term "mobile computing" reached a peak two years after publication of the HR, both in the category of "Education" (Ed) and also for "Colleges & Universities" (C&U).

However, this was not the case for the technology "open content." The popularity of the term declined after the peak

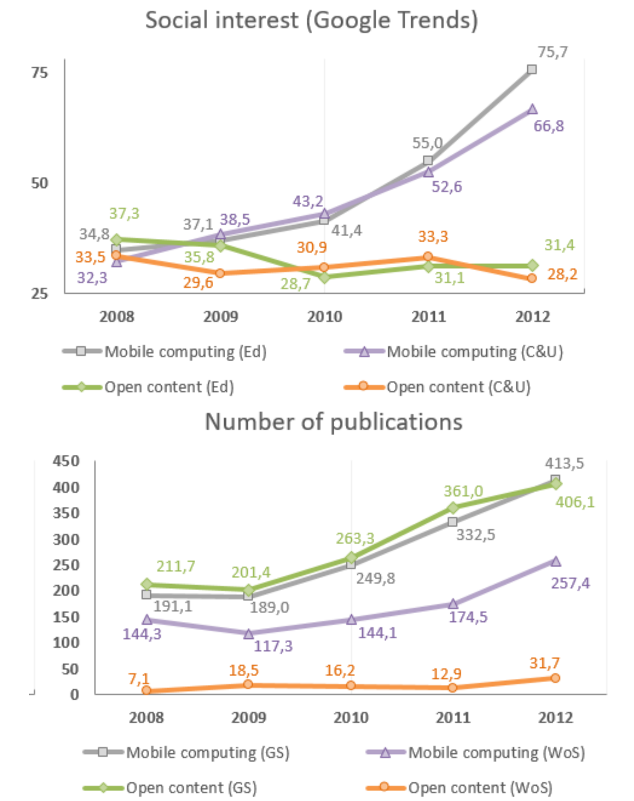

FIGURE 1. Social interest and scientific impact of the technologies predicted in the HR2010.

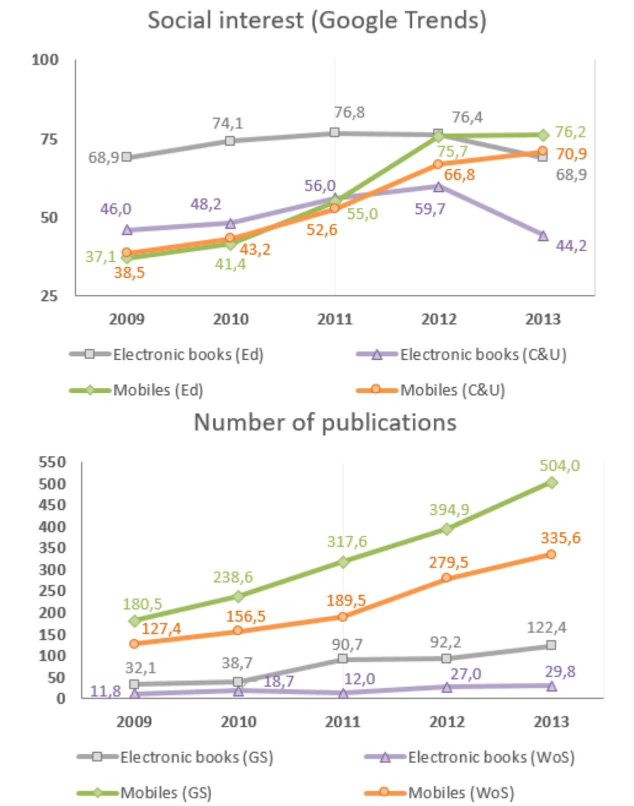

FIGURE 2. Social interest and scientific impact of the technologies forecasted in the HR2011.

observed in 2008. Regarding the scientific impact measured from the number of publications in GS and in WoS, the results were found to support the prediction made in the HR, except for the slight decline observed for the technology of "open content" in WoS one year after the publication of the report.

Figure 2 shows how the year of publication of HR2011 matches the peak of popularity measured by GT, for the technology "electronic books" in the "Ed" category, and one year later for the "C&U" category. We also observed that the number of publications on this technology found in the WoS and in GS increased during the two years following publication of the report. Regarding the term "mobiles," there was found to be an increase in search volume more than one year after publication of the report, especially in the "Ed" category, which appears to be accompanied by a rise in scientific production relating to this technology.

The results shown in Figure 3 reflect an increase in the social interest in the technology "mobile app," reaching maximum values after publication of the report. For the technology of "tablet computing" the maximum popularity occurred the year of publication of the HR2012. On the other hand, the scientific production relating to these technologies was found to increase after publication of the report.

The search volume in the "MOOC" technology represented in Figure 4 reached its highest values approximately one year after publication of the HR2013. As shown in the previous section, after 2012 social interest in the technology "tablet computing" gradually declined. Regarding the scientific impact, a steady increase in the number of publications was observed, both in GS and in WoS, during 2014 and 2015 for the technology of "MOOC" and in WoS for "tablet computing" technology.

The social interest in the terms analyzed in Figure 5 steadily increases over the interval of years considered, reaching a peak in 2015 for the case of the "flipped classroom" technology, whereas for "learning analytics" technology the maximum popularity occurred around 2016. Regarding scientific production, an increase in the number of publications was observed one year after publishing the report, which, in the case of studies on GS, intensified during 2016.

The results presented in Figure 6 show that the social interest on both technologies remains constant over the entire period. On the other hand, the number of publications on the "flipped classroom" continues to grow, as shown previously. In addition, the scientific production relating to the "BYOD" technology has also increased slightly after publication of the report.

IV. DISCUSSION

Table 2 analyzes whether the predictions made by the HRs were accompanied by a rise in social interest in said technologies. This was done by comparing the social interest during

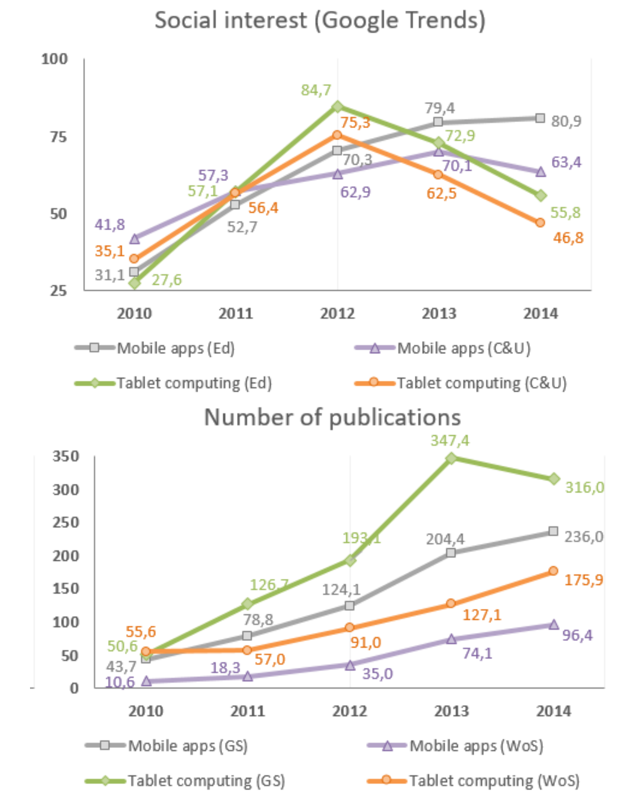

FIGURE 3. Social interest and scientific impact of the technologies forecast in the HR2012.

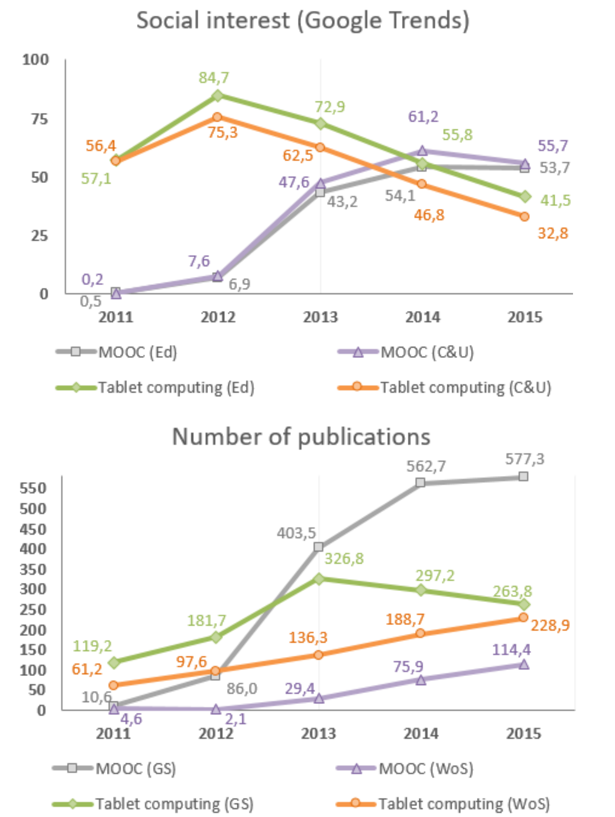

FIGURE 4. Social interest and scientific impact of the technologies forecast in the HR2013.

TABLE 2. Relationship between the HR prediction and social interest.

	2 years before		2 years after	
	Education	Colleges & Universities	Education	Colleges & Universities
Mobile computing (HR2010)	▲ 5,5	▲ 7,7	▲ 23,9	▲ 16,5
Open content (HR2010)	▼ -7,9	▬ -0,7	▬ 2,6	▬ -0,1
Electronic books (HR2011)	▲ 5,3	▲ 8,9	▬ -4,1	▬ -4,0
Mobiles (HR2011)	▲ 15,8	▲ 11,8	▲ 20,9	▲ 16,3
Mobile apps (HR2012)	▲ 28,4	▲ 13,4	▲ 9,9	▬ 3,8
Tablet computing (HR2012)	▲ 42,3	▲ 29,6	▼ -20,3	▼ -20,7
MOOC (HR2013)	▲ 39,5	▲ 43,6	▲ 10,7	▲ 10,9
Tablet computing (HR2013)	▬ 2,0	▬ -3,4	▼ -24,3	▼ -22,7
Flipped Classroom (HR2014)	▲ 23,8	▲ 12,0	▬ -1,7	▲ 9,6
Learning analytics (HR2014)	▲ 12,6	▲ 5,0	▬ 3,0	▬ -0,2
BYOD (HR2015)	▬ -0,8	▬ 0,8	▬ 0,5	▬ 3,6
Flipped Classroom (HR2015)	▲ 6,4	▲ 11,8	▼ -5,5	▬ -0,4

Note: ▲: increase in RSV of more than 5 points; ▬: increase or decrease in RSV lower than 5 points and ▼ decrease in RSV of more than 5 points.

the year of publication of the HR, with the interest two years before and two years after publication of the report. Three trends can be identified from the results:

a) Technologies for which the social interest increases in the year of publication of the report and declines or remains constant after that time. These predictions can be considered as the most successful ones, in that they are accompanied by the greatest social impact in the year of publication of the report. This would be the case for "electronic books," "mobile applications," "tablet computing" (HR2012), "flipped classroom," and "learning analytics."
b) Technologies for which the social interest increases during the year of publication of the report and continues to rise after that. These predictions can be considered to have a moderate success, since the impact extends after the short-term (one year or less). This group includes: "mobile computing," "mobiles," and "MOOC."
c) Technologies for which the social interest declines in the year of publication of the report, after which it remains constant or decreases further still. These predictions are the least successful and were made for the technologies: "open content," "tablet computing" (HR2013), and "BYOD."

On the other hand, Table 3 can be used to determine the success of the predictions made by HR based on the evolution of the scientific production, one or two years after publication of the report, about the predicted technologies.

The analysis consisted in comparing the number of publications at these two time points with the mean number of publications recovered for the year in which the report was published and for the previous two years. The results can be gathered in three categories:

a) Difference of 100 or more publications in GS and 50 in WoS, the year following publication of the HR. Those considered to be successful predictions in this

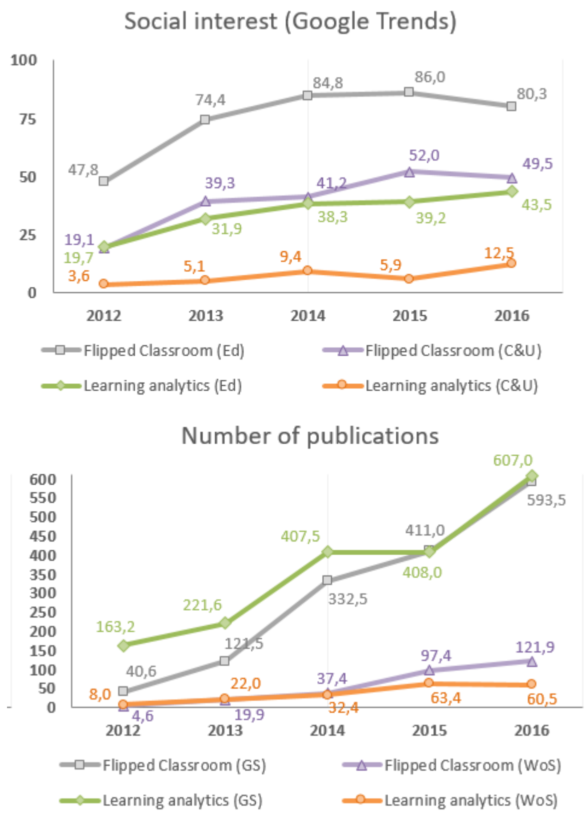

FIGURE 5. Social interest and scientific impact of the technologies forecast in the HR2014.

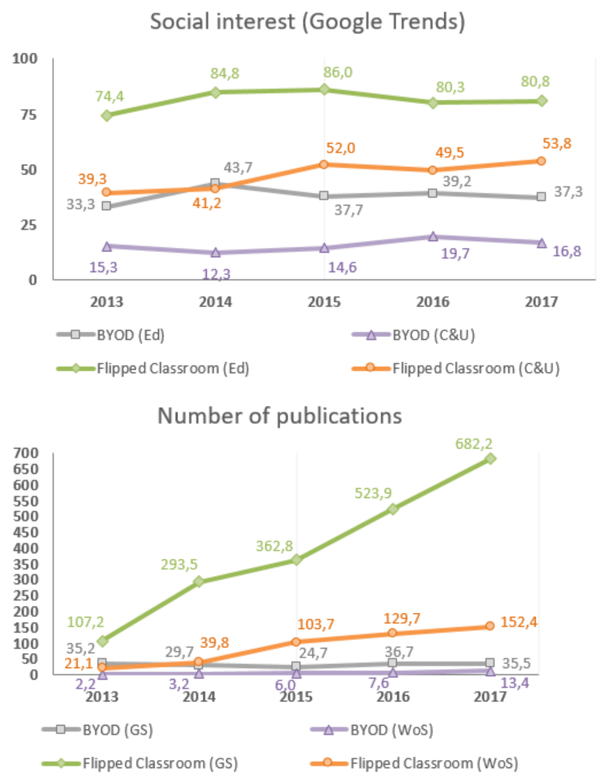

FIGURE 6. Social interest and scientific impact of the technologies forecast in the HR2015.

TABLE 3. Effect of the HR prediction on the scientific impact.

	1 year after		2 years after	
	Google Scholar	Web of Science	Google Scholar	Web of Science
Mobile computing (HR2010)	123	39	204	122
Open content (HR2010)	136	-1	181	18
Electronic books (HR2011)	38	13	69	16
Mobiles (HR2011)	149	122	258	178
Mobile apps (HR2012)	122	53	154	75
Tablet computing (HR2012)	224	59	192	108
MOOC (HR2013)	396	64	411	102
Tablet computing (HR2013)	88	90	55	131
Flipped Classroom (HR2014)	246	77	429	101
Learning analytics (HR2014)	144	43	343	40
BYOD (HR2015)	7	4	6	10
Flipped Classroom (HR2015)	269	75	428	98

Note: : difference in number of publications equal to or less than 0; : increase in the number of publications less than 25; : increase in the number of publications equal to or higher than 25 and lower than 50; : increase in the number of publications equal to or higher than 50 and lower than 100 : increase in the number of publications equal to or higher than 100.

TABLE 4. Classification of the technologies in relation to their social and scientific impact.

		Scientific impact		
		HIGH	MEDIUM	LOW
Social interest	HIGH	Mobile apps (HR2012) Tablet computing (HR2012) Flipped Classroom (HR2014) Flipped Classroom (HR2015)	Learning analytics (HR2014)	Electronic books (HR2011)
Social interest	MEDIUM	Mobiles (HR2011) MOOC (HR2013)	Mobile computing (HR2010)	
Social interest	LOW		Open content (HR2010) Tablet computing (HR2013)	BYOD (HR2015)

category correspond to: "mobiles," "mobile applications" "tablet computing (HR2012)," "MOOC," and "flipped classroom."

b) Difference of 100 or more publications in GS or 50 in WoS, the year following the publication of the HR (or difference of 100 or more publications in GS and 50 in WoS two years following the publication of the HR). These were considered as moderately successful predictions as the impact occurred in the medium term. This group corresponded to the technologies "mobile computing," "open content," "tablet computing (HR2013)" and "learning analytics."

c) Difference of less than 100 publications in GS and 50 in WoS, during the two studied years. These predictions were considered as not very successful and corresponded to "electronic books" and "BYOD."

In Table 4 we have classified the technologies in relation to the two previous criteria. The results show that 50% of the technologies considered here present a similar social and scientific impact.

On the other hand, technologies outside the main diagonal have had a different social and scientific impact. The clearest example of these is the case of the "Electronic books," for which the social interest was high in 2011 although it had a low scientific impact.

V. CONCLUSIONS

In this paper, we have identified the 12 educational technologies, which according to Horizon Reports Higher Education published between 2010 and 2015, have impacted higher education in the short term. The trend in social interest has been analyzed by measuring the RSV provided by Google Trends. The scientific impact of these technologies was also calculated based on the number of publications in Google Scholar and in the Web of Science, in order to determine whether the information published in these reports correlates with the evolution of the aforementioned indicators or not.

The study of both of these criteria verifies the success of the predictions made in the HRs. The most successful forecasts were made for technologies characterized as having a high social interest and scientific impact. Unsurprisingly, in these cases, the educational society has shown the most interest in the predicted technologies, as proven by the number of searches in Google and, in turn, these technologies have been the most studied by researchers.

In addition, using both criteria to evaluate these technologies allows anomalous situations to be identified, such as the case of the tablet computing. For example, the scientific impact of the tablet computing (HR2013) may not be due to the effect of technology implementation in 2013, but instead it could be caused by the social interest in tablet computing when it first appeared. As a result, researchers might have regarded this technology as a new field of observation and research, and studying in depth its educational possibilities and limitations, to discover possible uses and different forms of application.

Moreover, this study demonstrates the value of Google Trends to improve the predictions made in the field of education. Given that Google Trends can assess the social interest at a given moment in time, its use to forecast the present can avoid errors in short-term predictions. In the case that concerns us here, Google Trends allows the "popularity" of several technologies and their historical evolution to be compared. Thus, the forecasts made by the HRs could take into account, to some extent, the evolution of social interest (measured through Google Trends or through some other procedure).

The main limitations of this study are the lack of transparency of the Google Trends methodology [13] and the limitation to the number of characters allowed in its query. The limitation in the number of characters allowed in the search equation also affects to Google Scholar. In addition, other limitations are related to the design of information retrieval equations, conditioned by the need to limit the search in Google Scholar and the Web of Science to educational publications, which may cause a loss of relevant works.

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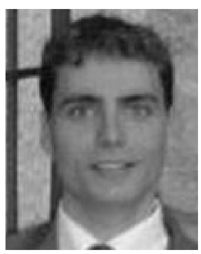
SERGIO MARTIN (S'06–M'10–SM'15) received the Ph.D. degree from the Electrical and Computer Engineering Department, Industrial Engineering School, UNED. He was a Computer Engineer with the Distributed Applications and Systems, Carlos III University of Madrid, receiving Honor marks in his final project. He is currently a Technical Computer Engineer with the Polytechnic University of Madrid. He has been teaching subjects related to microelectronics and digital electronics at the Industrial Engineering School, UNED, since 2007. Since 2002, he has been participating in national and international research projects related to mobile devices, ambient intelligence, and location-based technologies and in projects related to e-learning, virtual and remote labs, and new technologies applied to distance education. He has published over 100 papers both in international journals and conferences.

ESTHER LÓPEZ-MARTÍN received the degree (Hons.) in pedagogy and the Ph.D. degree in science of education from the Complutense University of Madrid, Spain. She has been a Visiting Research Fellow with the Teachers College, Columbia University, New York, NY, USA, and the Helsinki School of Economics, Finland. She is currently a Professor with the Department of Methods of Research and Diagnosis in Education II, National University of Distance Education (UNED). She is also with the Education System Measurement and Assessment Research Group, Complutense University, Madrid, and the Systems of Psycho-Educational Guidance and Competencies of Guidance Practitioners Research Group, UNED. She received the Extraordinary Ph.D. Award.

AFRICA LOPEZ-REY is currently an Industrial Engineer, Electronic and Automatic Specialty. She received the Prize for the Best Teaching Material in Experimental Sciences of the Council of the UNED in 1999. She is currently an Associate Professor of systems engineering and automation with the Department of Electrical Engineering, Electronics and Control, ETSII, UNED. He has participated as a collaborator in several research projects that have led to articles and communications presented at conferences and journals, in which an active part has participated both as rapporteur and co-author.



JOAQUÍN CUBILLO received the Ph.D. degree the Electrical and Computer Department, UNED. His professional career started as a technical engineer of telecommunications with the Laboratory of Electric Calibration, Castilla y Leon, in 2001, where he was involved in developing electric essays, projects of I+D, and essays of electromagnetic compatibility. In 2002, he joined the firm GESMASA SL, for which he did jobs with technology of location, and situation planes and data. In 2004, he joined the I+D+I Team, ORBIS Electric Technology, as an Electric Engineer, where he coordinated the jobs necessary to pass to take part of the directive 2002/95/CE also known as ROHS about dangerous substances. In 2005, he joined the Scientist Investigations Superior Centre CSIC, Acoustic Physics Institute, where he was involved in developing different virtual instrumentation and remote control equipment. Since 2006, his career focused on the world of teaching with the Integrated Training Centre Santa Catalina, Aranda de Duero, where he is currently a Professor of electronic systems, teaching modules as digital and microprogramable electronic, development of electronic projects, and applied electronics, the director of several training courses for teachers, the Head of the Management Team for studies and the coordinator of new information technologies and communications. He is currently a Telecommunications Engineer.

ALEXIS MORENO-PULIDO received the Library Science degree from the University of Salamanca. He was with the Library of the Cervantes Institute, Manchester, the Department of European Studies of the Senate, the Spanish ISBN Agency, and the National Library of Spain. He is currently responsible for the North Campus Library, UNED, where he carries out research support and bibliometric advice for decision making.

His research interests are focused on the evaluation of research activity using bibliometric indicators and innovative approaches to information literacy instruction.

MANUEL CASTRO (M'87-SM'94-F'08) received the degree in industrial engineering from the Industrial Engineering School, Madrid Polytechnic University (UPM), and the Ph.D. degree in engineering from UPM. He is currently an Electrical and Computer Engineering Educator with the Spanish University for Distance Education (UNED). He has received the Extraordinary Doctoral Award from the UPM, the Viesgo 1988 Award to the Doctoral Thesis improving the Scientific Research about the Industrial Process Electricity Application, the 1997 and 1999 UNED's Social Council Award for the Best Didactic Materials in Experimental Sciences, and the 2001 Award for the Innovative Excellence in Teaching, Learning and Technology from the Center for the Advancement of Teaching and Learning.

He is currently a researcher, a coordinator, and the director in different projects, ranging from systems applications of simulation techniques, solar system, advanced microprocessor system simulation to telematics, distance learning applications and systems, and computer-aided electrical engineering. He is currently a Senior Technical Director. He is with the Electrical and Computer Engineering Department, Spanish University for Distance Education (UNED), as a Professor of electronics technology. He was UNED's New Technologies Vice Rector, the Director of the Information Services Center, UNED, and the Research, Doctorate Vice Director, and the Academic Affairs Vice Director of the Engineering School, UNED, and the Director of the Department. He was with Digital Equipment Corporation as Senior System Engineer for five years. He has published different technical, research, and teaching books and articles for journals and conferences, and multimedia materials and radio and TV programs. He was a member of the Administration Committee from 2005 to 2012 of the IEEE Education Society and the Vice Chair from 2011 to 2012 of the IEEE Education Society, the Founder and the Past Chairman of the Spanish Chapter of the IEEE Education Society from 2004 to 2006, and the Chair of the IEEE Spain Section from 2010 to 2011. He is a fellow member of IEEE for contributions to distance learning in electrical and computer engineering education. He is the Vice President of the Board of the Spanish International Solar Energy Society (ISES). He is with the Organizing Committee of the IEEE EDUCON, the IEEE Frontiers in Education Conference (FIE) International and Europe Chair, from 2000 to 2006, ISES, the Tecnologías Aplicadas a la Enseñanza de la Electrónica (TAEE), and SAAEI conferences, a program and planning committees' member and a reviewer and the chairman of several ones. He was the Co-Chair of the Engineering Education Conference in 2010, the TAEE 2010 and the International Conference on Engineering and Computer Education in 2005. He is the Co-Chair of FIE 2014 to be organized in Madrid, Spain, by the IEEE and the ASEE. He has received the IEEE EDUCON 2011 Meritorious Service Award (jointly with E. Tovar) from the EDUCON 2011 Conference, the 2010 Distinguished Member Award of the IEEE Education Society, the 2009 Edwin C. Jones, Jr. Meritorious Service Award of the IEEE Education Society, the 2006 Distinguished Chapter Leadership Award, and the collective work inside the Spanish Chapter of the IEEE Education Society with the 2011 Best Chapter Award from the IEEE Region 8 and the 2007 Chapter Achievement Award from the IEEE Education Society. He is a co-editor of the IEEE-Revista Iberoamericana de Tecnologías del Aprendizaje and the Electronic Journal of Spanish Chapter of the IEEE Education Society.