

## *Trends of e-learning research from 2000 to 2008: Use of text mining and bibliometrics*

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### **Abstract**

This study investigated the longitudinal trends of e-learning research using text mining techniques. Six hundred and eighty-nine (689) refereed journal articles and proceedings were retrieved from the Science Citation Index/Social Science Citation Index database in the period from 2000 to 2008. All e-learning publications were grouped into two domains with four groups/15 clusters based on abstract analysis. Three additional variables: subject areas, prolific countries and prolific journals were applied to data analysis and data interpretation. Conclusions include that e-learning research is at the early majority stage and foci have shifted from issues of the effectiveness of e-learning to teaching and learning practices. Educational studies and projects and e-learning application in medical education and training are growing fields with the highest potential for future research. Approaches to e-learning differ between leading countries and early adopter countries, and government policies play an important role in shaping the results.

### **Introduction**

The impact of learning technology is expanding rapidly. Ambient Insight Research predicted US market demand for self-paced e-learning products and services will grow with a 12.8% compound annual growth rate and reach \$49.6 billion by 2014 (Ambient Insight Research, 2009). Lockwood (2007) observed e-learning publications from 2000 to 2006 and concluded e-learning development has passed the innovators and early adopters stages in the diffusion of innovations model (Rogers, 2003) and is now at the early majority stage, in which it becomes a mainstream activity.

In the history of e-learning, there is no single evolutionary tree and no single definition (Nicholson, 2007). As a research subject, e-learning is both multidisciplinary and interdisciplinary and covers a wide range of research topics, with scholars from different disciplines conducting e-learning related research ranging from content design to associated policy.

Given the field's diversity, this paper will first take an overview of e-learning research using bibliometric indicators, then classify e-learning research with text mining techniques, and, finally, construct evolutionary trends of e-learning research. This paper aims to answer the following questions:

Q1: What are the e-learning research bibliometrics?

Q2: What are the taxonomies and themes in e-learning research?

Q3: What are the trends and patterns of e-learning research?

This study provides a longitudinal as well as macro viewpoint on prestigious publications of e-learning by identifying topic taxonomy and themes across time. More importantly, it identifies trends in e-learning literature and topics yet to be studied in this multifaceted and growing field, leaving e-learning scholars better informed and able to contribute.

### *Definition of e-learning*

The term 'e-learning' has different meanings in different contexts (Nicholson, 2007). However, definitions of e-learning can be classified into two categories, the first focusing on network technology use. Rosenberg (2001, p. 28) defined e-learning as 'the use of internet technologies to deliver a broad array of solutions that enhance knowledge and performance'. Masie (2008, p. 379) similarly defined e-learning as 'the use of network technology to design, deliver, select, administer, and extend learning'.

The second category includes all electronic media. Wentling *et al* (2000, p. 5) defined e-learning as 'the acquisition and use of knowledge distributed and facilitated primarily by electronic means. This form of learning currently depends on networks and computers'. Govindasamy (2002, p. 288) stated that e-learning 'includes instruction delivered via all electronic media including the Internet, intranets, extranets, satellite broadcasts, audio/video tape, interactive TV, and CD-ROM'.

### *e-Learning research*

Conole and Oliver (2007) grouped e-learning research into four themes: pedagogical, technical, organisational and wider socio-cultural factors. Pedagogical research revolved around the pedagogy of e-learning and development of effective implementation models. Technical research discussed the development of technical architectures to support different forms of learning and teaching. Organisational research focused on organisational-level issues for developing successful learning organisations. Socio-cultural factors research cut across pedagogical, technical and organisational issues, focusing on the influence of policy drivers and funding steers, current or local agendas and initiatives.

Winn (2002) defined the evolution of educational technology research into four stages: (1) the age of instructional design, focusing on content; (2) the age of message design, focusing on format; (3) the age of simulation, focusing on interactions; and (4) the new age of research, focusing on learning environments. Mihalca and Miclea (2007) further concluded that trends in educational research were forged by the evolution of learning theories and technological changes. In addition, the authors noticed that focus shifted from instruction design to learning environment design.

These e-learning research themes were defined by scholars based on self-observations within their fields of expertise. Each author mentioned the complexity and interdisciplinary nature of e-learning research. Systematic inquiries are necessary to gain a holistic understanding of the field.

### *Bibliometrics*

Bibliometric analysis is a method for summarising the research reported in scientific literature by measuring certain indicators (Thelwall, 2008). It sums up publication information with quantitative statistics regarding growth of papers by year and citations, rankings of most prolific contributors, authorship patterns, rankings of geographical distribution of authors, rankings of most productive institutions, collaboration among institutions, range and percentage of references per paper, and frequency distribution of subject descriptors (Keshaval, Gireesh & Gowda,

2008). Bibliometrics enables researchers to generate quantitative information from large amounts of historical data; however, the approach has been criticised for its emphasis on numbers to the exclusion of actual content.

Some scholars have sought to remedy this disparity through content analysis. For example, Shih, Feng and Tsai (2008) studied research trends of cognitive studies in e-learning from 2001 to 2005. The authors selected five Social Science Citation Index (SSCI) journals as data sources and retrieved 444 articles for cross-analysis by publication year, journal, research topic and citation count. Furthermore, they chose 16 highly cited articles across different topics for further analysis. The study found 'Instructional Approaches', 'Learning Environment' and 'Metacognition' were the most popular research topics at that time. The categorical data were combined with bibliometric data from citation databases and the study provided valuable insights for educators and researchers.

Although content analysis can make up missing parts of traditional bibliometrics methodologies, it also creates difficulties for researchers in terms of time and labour. Researchers need a tool, like text mining, which fulfils the need for faster content analysis while generating categorisation.

#### *Text mining*

Text mining, an extension of data mining (Feldman & Dagan, 1995), is the process of extracting meaningful patterns from a set of unstructured texts. According to Fayyad, Piatetsky-Shapiro, Smyth and Uthurasamy (1996), text data mining is typically conducted in five steps: data selection, data cleaning, data transformation, data mining, and results evaluation and interpretation. The first three steps involve data processing. Data mining relies on computer-automated analysis. Results require domain experts for evaluation and interpretation.

Major applications of text mining include: automatic classification (clustering) (Kostoff *et al.*, 2007), information extraction (text summarisation) (Ou, Khoo & Goh, 2008) and link analysis (topic mapping) (Feldman & Sanger, 2007). These techniques provide tools that save time and effort in information processing and analysis.

The study reported herein followed this process to conduct automatic classification analysis of e-learning literature.

### **Method**

#### *Data collection*

The Web of Science was chosen as the source database for these reasons: first, the database collects journals from both the SCI and SSCI and includes only those journals with the highest impact in science or social science. Second, the Web of Science is a bibliometric database (Okubo, 1997) that makes detailed bibliometric analysis possible.

Two terms, 'e-learning' and 'elearning' were selected as keywords. For the purpose of this study, the search was limited to journal articles and proceedings papers. A total of 689 e-learning articles and proceedings were retrieved from 289 journals/proceedings (the detailed list can be retrieved from <http://edtech2.boisestate.edu/hungj/elearning/list.html>), with a search period of January 1, 1981 (the earliest date in the database)–December 31, 2008. All retrieved data were pre-processed, or 'cleaned', to remove redundant information such as page and issue numbers, publishers and author contacts. Processed data were then aggregated into fields and stored in the database. The following fields were then created in the database: article identity number, article title, article abstract, source journal, institution, country and publication year.

#### *Data analysis*

##### *Basic bibliometrics*

Summary publication bibliometrics on e-learning were generated from the aggregate records (Keshaval *et al.*, 2008). A set of bibliometric indicators (eg, quantitative growth of papers by year,

ranked list of geographical distribution of articles and ranked list of most prolific source journals) were applied to describe the characteristics of the retrieved e-learning research.

### Text mining and clustering analysis

SAS (Institute Inc., Cary, NC, USA) Enterprise Miner 5.3 was employed to conduct text mining in this study, and grouped documents based on abstract similarities. SAS Enterprise Miner also agglomerated clusters in a hierarchical tree structure, which illustrated a taxonomy of the retrieved e-learning studies based on the mining results. Hierarchical agglomerative clustering was applied for an agglomerative clustering algorithm (Jain, Murthy & Flynn, 1999) to generate the taxonomy structure. All results are presented in figures in the following section.

## Results

### *Publication time trends*

Figure 1 summarises the number of research articles by year from 2000 to 2008. The solid line represents the number of articles across years and the dashed line represents the moving average trend line. Results revealed two major growth periods of e-learning research. The first period is from 2001 to 2005, during which publications of e-learning increased from 15 to 101—a 154.7% compound growth rate. During the second period, publications of e-learning grew from 107 in 2007 to 121 in 2008.

### *Subject area*

A majority of published e-learning studies focused on two subject areas: computer science (46.22%) and Education (31.22%). Additional studies were conducted in fields like medical education (7.70%), engineering (6.08%), library science (5.41%) and others (2.16%).

### *Prolific universities*

Based on author affiliations, the study identified countries producing the most publications on e-learning from 2000 to 2008. The five most prolific countries in e-learning research were England (12.97%), USA (12.43%), Taiwan (10.27%), China (8.38%) and Germany (7.16%).

### *Prolific journals*

Journals with the most e-learning articles were *Lecture Notes in Computer Science* (LNCS) (19.73%), *Computers & Education* (CE) (6.62%), *British Journal of Educational Technology* (BJET) (5.00%), *Educational Technology & Society* (ETS) (4.86%) and *Lecture Notes in Artificial Intelligence*

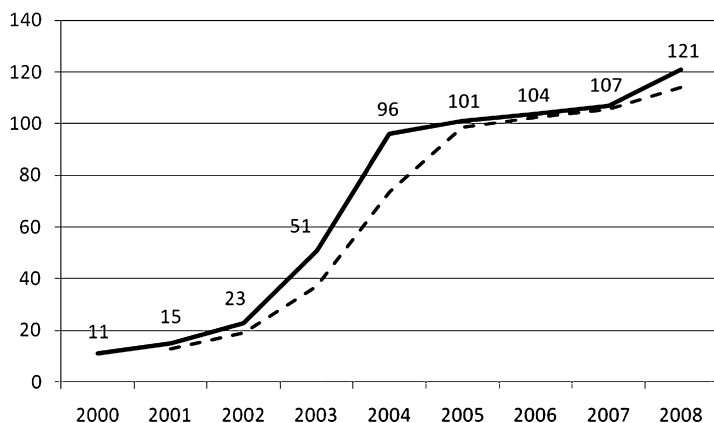


Figure 1: e-Learning publication trends from 2000 to 2008

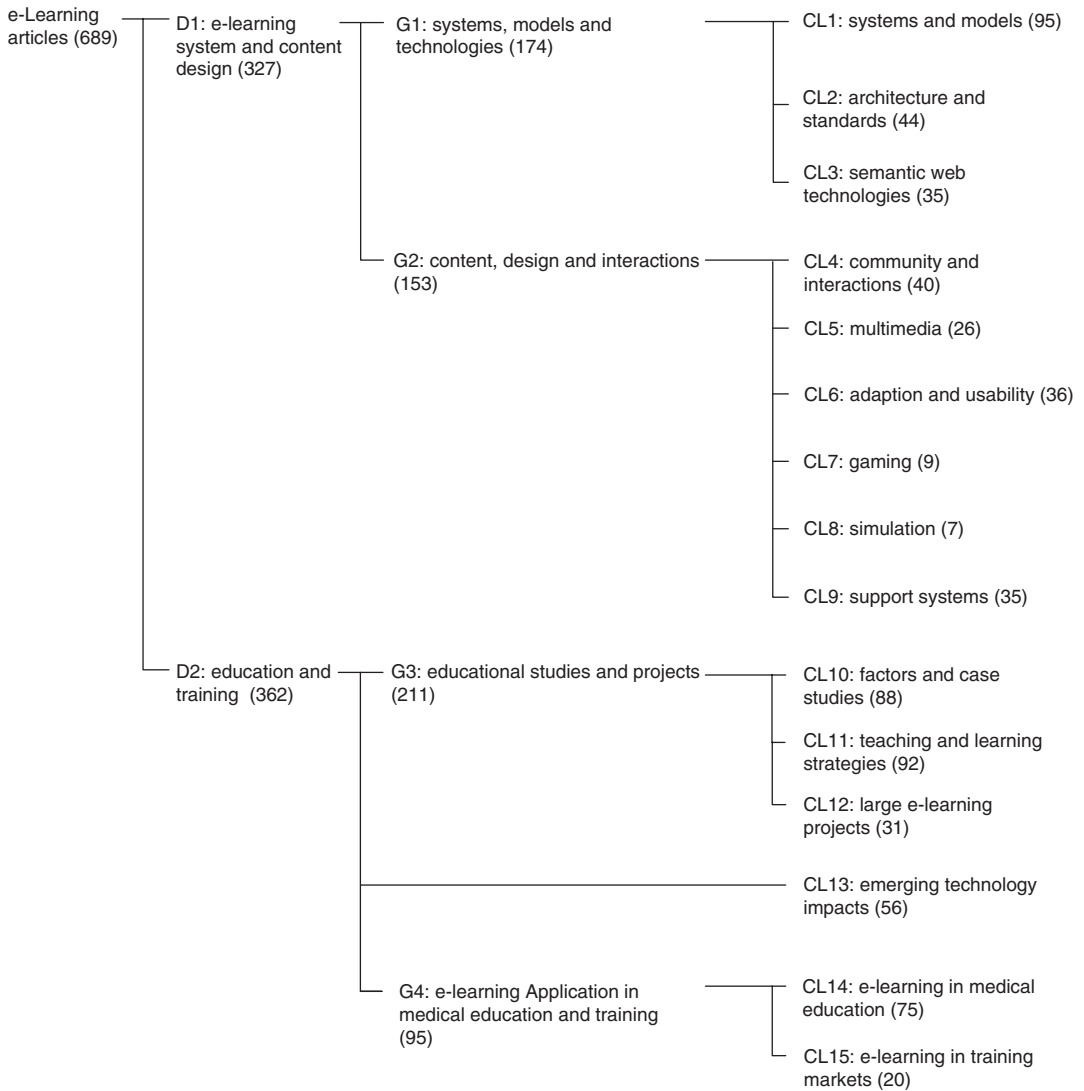


Figure 2: Taxonomy of e-learning research

(LNAI) (3.24%). Together these journals have contributed 39.46% of the related literature in this database. Except for LNCS (19.73%), which only publishes proceedings papers, the research was divided fairly evenly.

#### *Taxonomy of e-learning research*

Figure 2 shows the results of clustering analysis. This method classified articles into a hierarchical structure based on similarity of abstracts. A multilevel, 15-cluster hierarchical structure was generated by clustering analysis. These clusters were interpreted by two domain experts with 16 years combined e-learning research experience to ensure interrater reliability (Flem, McCracken & Carran, 2004).

As illustrated in Figure 2, beginning at the rightmost column, all articles were divided into 15 clusters (CL1-CL15), and those 15 clusters were organised into larger groups and domains.

The first group, systems, models and technologies (G1, 174 articles), contains clusters 1 through 3. They are as follows:

CL1 (95 articles): articles focusing on the construction of e-learning systems and models from either a technical or an educational perspective.

CL2 (44 articles): studies discussing e-learning platform or system architectures and standards.

CL3 (35 articles): studies on the application of Semantic Web technology.

The second group, content, design and interaction (G2, 153 articles), includes clusters 4 through 9:

CL4 (40 articles): articles discussing e-learning community and interaction.

CL5 (26 articles): application of multimedia in e-learning.

CL6 (36 articles): issues of adaption and usability in e-learning.

CL7 (9 articles): application of gaming in e-learning.

CL8 (7 articles): use of simulation in e-learning.

CL9 (35 articles): support system design and development.

These first two groups, G1 and G2, are subsequently combined into a larger domain: e-learning system and content design (D1, 327 articles).

The following are the clusters in G3 (educational studies and projects, 211 articles): CL10 (88 articles): e-learning case studies and related factors.

CL11 (92 articles): teaching and learning strategies and how to improve the effectiveness of e-learning and student motivation.

CL12 (31 articles): large-scale national or state-level e-learning projects.

CL13 (56 articles) is made up of studies discussing emerging technologies' impacts in educational fields and is not in any group.

The final two clusters are in G4 (e-learning application in medical education and training, 95 articles):

CL14 (75 articles): e-learning research in medical education.

CL15 (20 articles): e-learning research on training and lifelong learning.

Finally, G3, CL13 and G4 are merged into the second large domain: education and training (D2, 362 articles).

According to the results in Figure 2, the top three clusters by number of e-learning publications are CL1: systems and models (95 articles, 13.79%), CL11: teaching and learning strategies (92 articles, 13.35%) and CL10: factors and case studies (88 articles, 12.78%). These three clusters compose 39.91% of the e-learning studies.

### *Time trends of article clusters*

Figure 3 shows the results of a time-trend analysis of the publications by cluster. Trends indicate topics of growing or diminishing research interest. The following topics were identified as those with growing interest: systems & models (CL1), factors and case studies (CL10), teaching and learning strategies (CL11), large e-learning project (CL12), e-learning in medical education (CL14) and e-learning in training and lifelong learning (CL15). The number of publications on these topics showed a generally upward trend in 2007 and 2008.

Publications on architectures and standards (CL2), multimedia (CL5) and support systems (CL9) have decreased in the past 2 years.

The number of publications in domain 2 (Education & Training), which includes educational studies and projects (G3) and e-learning application in medical education and training (G4), showed consistent growth from 2000 through 2008, while there was no significant trend in domain 1 (e-learning system and content design).

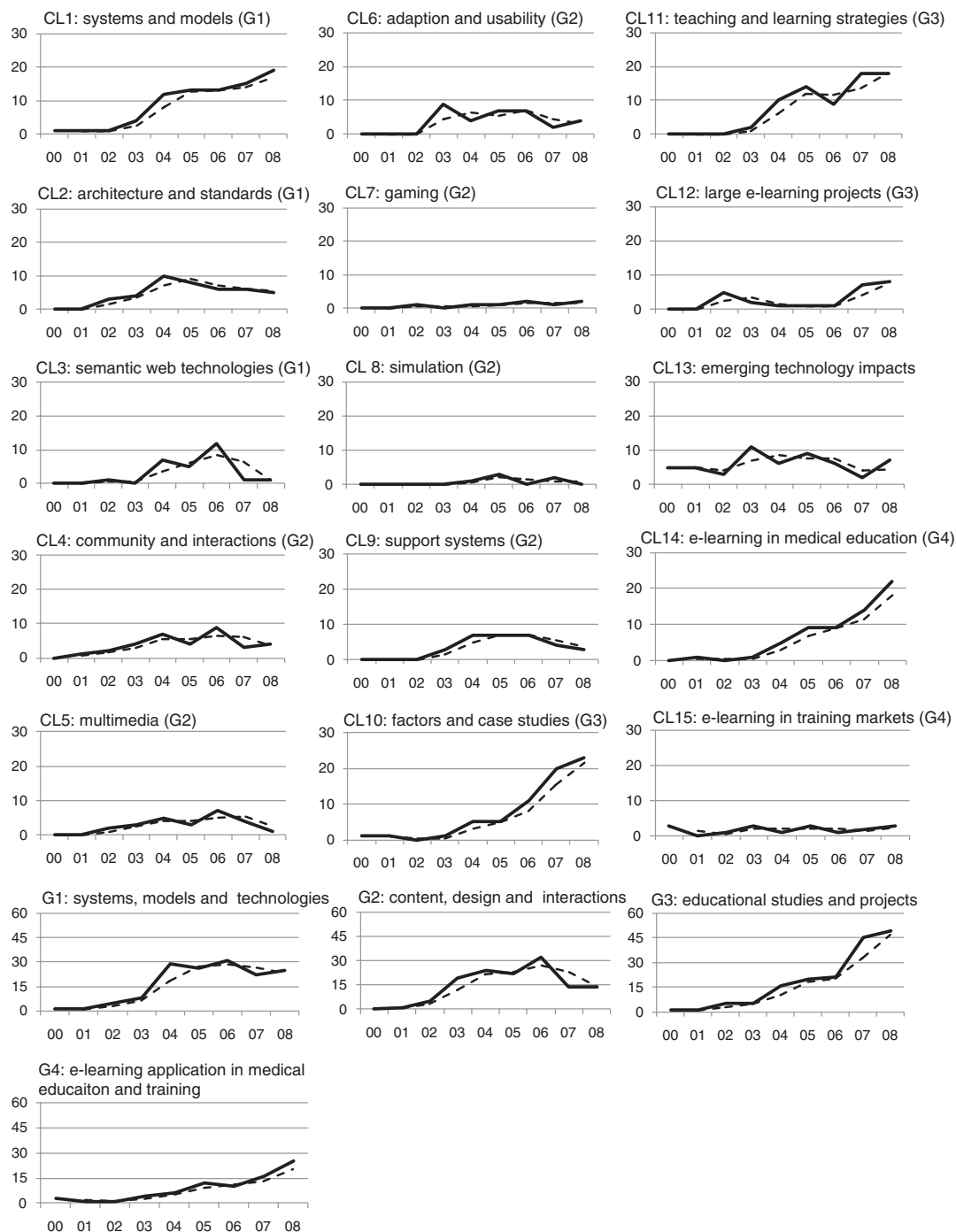


Figure 3: Time trends of clusters and groups



No other clusters showed significant upward or downward trending.

#### *Publication distribution in journals and countries*

Figure 4 aggregated data using the following standards:

1. The vertical axis lists 27 journals, which are a collection of the top three prolific journals in each cluster.
2. The horizontal axis contains all 15 clusters.
3. Ten countries are listed alphabetically at the bottom of the figure, and each is assigned a circled number. This list is comprised of the top three most prolific countries from each cluster. The position of each country's circled number in the figure indicates the quantity of articles from that country for each cluster and journal title. The figure revealed research strengths of each country in e-learning publications as well as the topic preferences of each journal.

The results revealed the following: England ranks in the top three prolific countries for 10 clusters (CL1, 3, 4, 7, 10, 11, 12, 13, 14 and 15); Taiwan ranks in nine clusters; China ranks in eight clusters; USA ranks in seven; Germany, Italy and Spain rank in four; Japan is in three; South Korea is in two; and Australia is in the top three prolific countries in one cluster.

Publications from scholars in England focused primarily on educational journals such as BJET and Innovations In Education And Teaching International (IETI), while scholars in China and South Korea mainly published e-learning articles in computer science journals such as LNAI and LNCS. Taiwan published e-learning articles in both computer science and educational journals.

Figure 4 revealed certain journals published more e-learning articles from specific countries. BJET published many e-learning articles by scholars in England and USA. LNCS published large numbers of articles from scholars in China. Training & Development (TD) published exclusively from USA. CE, ETS, Expert Systems With Applications (ESA) and Journal of Information Science and Engineering (JISE) all published multiple e-learning articles from scholars in Taiwan.

### **Discussion**

This section discusses findings in overall themes, research trends and global research approaches.

#### *Overall themes*

##### *Two major growth stages*

According to the results in Figure 1, there were two major growth stages in e-learning research. One occurred from 2002 to 2004 and the other from 2007 to 2008. Examining topic trends, the first stage seems to have been a general taking-up of the topic of e-learning in its many aspects. One major factor driving research growth in this period was the initiation of learning management systems such as Moodle, which began in 2001, and Blackboard, which began in 2000. WebCT started in 1995 but was not widely adopted by higher education institutions until 2003 (History of Virtual Learning Environments, 2009).

In the second growth period, research topics narrowed, shifting in focus from the technical aspects of e-learning to its educational applications. The following topics (Figure 3) increased during this period: systems and models (CL1), factors and case studies (CL10), teaching and learning strategies (CL11), large e-learning projects (CL12), emerging technology impacts (CL13) and e-learning in medical education (CL14). Interestingly, no articles in these clusters were published in either of the top two most prolific technical journals: LNAI and LNCS.

#### *Implications*

The results implied three conclusions: first, results support Lockwood's conclusion (Lockwood, 2007) that e-learning research is at the early majority stage in the diffusion of innovation model, meaning that scholars, except for early adopters, now research e-learning too.



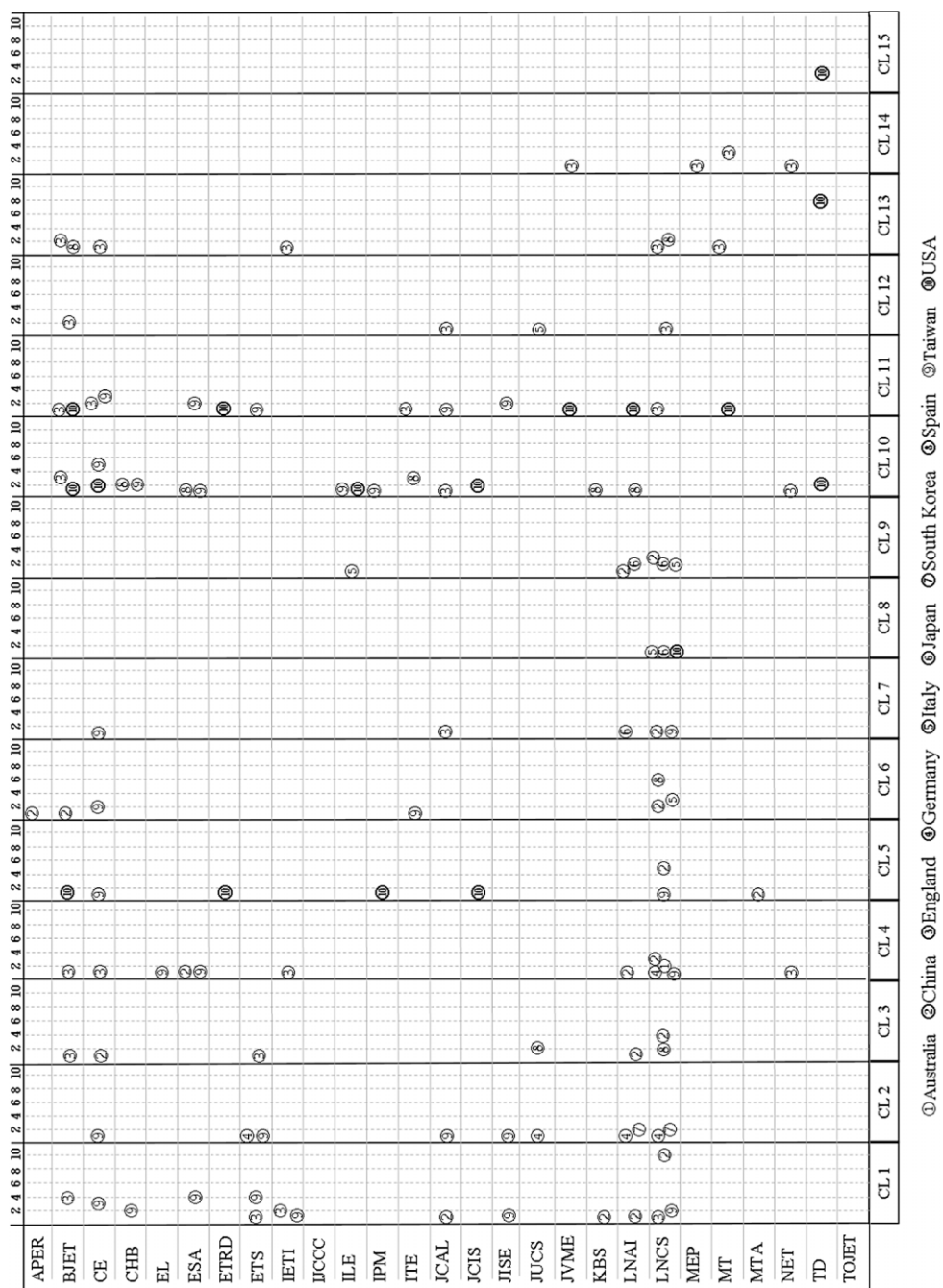


Figure 4: Publication distributions in journals and countries

Second, scholars have shifted their focuses from issues of the effectiveness of e-learning to teaching and learning practices. Comparing the effectiveness of e-learning with that of traditional instruction is no longer a popular topic. Related evidences can be found via growing research articles in large e-learning project, factors and case studies and Teaching & Learning Strategies.

Third, educational studies and projects (G3) and e-learning in medical education (CL14) have become hot topics, though only a few educational journals are in the SSCI list. More educational journals should be added to the SSCI list to accommodate these growing publication needs.

### *Research trends*

#### *e-Learning research taxonomies and themes*

Compared with the increased topics in Figure 3, the following topics decreased in 2007 and 2008: architectures and standards (CL2), Semantic Web technologies (CL3), multimedia (CL5) and support systems (CL9). The results indicated studies on e-learning standards and technical architectures reached their highest number between 2004 and 2006, but they are not currently hot topics in these SSCI/SCI journals. However, systems and models (CL1) is still popular in system, models and technologies (G1).

### *Implications*

Current e-learning theories stress the importance of situated cognition (Hung, 2002) and personalised learning (Magoulas & Chen, 2006). This results in decreasing studies in CL2 and CL3. In addition, technologies create new or different forms of learning and enable instructors to reach more audiences with varying backgrounds. All these factors increased studies on developing models for effectiveness within various environments and mapping different teaching and learning strategies. The results also explained why studies on educational studies and projects and e-learning application in medical education and training (G4) are growing.

### *Global research approaches*

Figure 4 revealed research strengths among countries. England and USA are the leading countries on e-learning development. It is no surprise they are the most prolific countries on e-learning research. Instead of focusing on technical aspects, scholars in these two countries are more concerned about the educational side. Conversely, China's approach to e-learning research is technology oriented. One major reason might be that China is at the innovators or early adopters stage in the diffusion of innovation model (Zhang, 2005). Taiwan's scholars studied e-learning from both educational and technical standpoints. This is noteworthy because only 0.61% of courses were fully online in Taiwan's higher education institutions (Zhang & Hung, 2006), a miniscule percentage compared with the other leading countries. For many countries, e-learning is valued and utilised as a driving force to speed up the technical, industrial and economic development of society. Related research generally impacts local e-learning development. However, Taiwan's government funding enhanced only e-learning research in Taiwan, with minimal practical impact (Zhang & Hung, 2006, 2009). Results also found associations between journals and specific countries. However, there is no further evidence to explain these associations.

### *Implications*

The results of Figure 4 showed different geographic regions have different e-learning research foci. The related e-learning environments determined types of studies in different countries. Scholars in leading countries on e-learning development focused on its educational aspects. Scholars in early adopter countries tended to study e-learning from technical perspectives. In addition, government policies play an important role in shaping the results.

Moreover, the growth of the e-learning market will be strong in the next 5 years. However, e-learning application in training (CL15) is not a hot topic in SCI/SSCI journals. More research efforts are required to meet the growing needs.

#### *Limitation of the study*

The results and conclusion are limited and not intended to be exclusive. SCI/SSCI journals adopt stringent journal reviewing criteria. Articles might take 2 years from submission to publication. In addition, the SCI/SSCI database does not collect conference proceedings in education. Therefore, findings in this study may not reflect the most recent research trends.

Research on learning and technology has been carried out since the 1960s, and even before that date, this study used only two search terms to analyse e-learning publications from 2000 to 2008 collected in the SCI/SSCI databases at that time. Future studies with greater resources, using more search terms, are needed to expand these findings.

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## Appendix A: Full Journal Titles of Figure 4

<i>Journal Title</i>	<i>Abbreviation</i>
Asia Pacific Education Review	APER
British Journal of Educational Technology	BJET
Computers & Education	CE
Computers in Human Behavior	CHB
Electronic Library	EL
Expert Systems with Applications	ESA
ETR&D-Educational Technology Research and Development	ETRD
Educational Technology & Society	ETS
Innovations In Education and Teaching International	IETI
International Journal of Computers Communications & Control	IJCCC
Interactive Learning Environments	ILE
Information Processing & Management	IPM
IEEE Transactions on Education	ITE
Journal of Computer Assisted Learning	JCAL
Journal of Computer Information Systems	JCIS
Journal of Information Science and Engineering	JISE
Journal of Universal Computer Science	JUCS
Journal of Veterinary Medical Education	JVME
Knowledge-Based Systems	KBS
Lecture Notes in Artificial Intelligence	LNAI
Lecture Notes in Computer Science	LNCS
Medical Engineering & Physics	MEP
Medical Teacher	MT
Multimedia Tools and Applications	MTA
Nurse Education Today	NET
Training & Development	TD
Turkish Online Journal of Educational Technology	TOJET