Mapping the Evolution of eLearning from 1977–2005 to Inform Understandings of eLearning Historical Trends

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Abstract*: While there have been very limited studies of the educational computing literature to analyze the research trends since the early emergence of educational computing technologies, the authors argue that it is important for both researchers and educators to understand the major, historical educational computing trends in order to inform understandings of current and future eLearning trends. This study provides the findings of an analysis of 2,694 journal articles published between 1977 and 2005 in four major, international educational computing journals. It provides the platform for a subsequent analysis for the period 2006–2013 and beyond, as future educational computing research is published. The journal articles analyzed were categorized according to their research themes. Subsequently, clustering analysis, multi-dimension scale analysis, and research diversity analysis were performed on the categorized results to explore the research trends. The research literature analysis confirmed that there were identifiable evolutionary trends dating from 1977, and, importantly, the analysis highlighted that each key breakthrough in technology was accompanied by increased educational research about those technologies to inform educational practices. Importantly, two major driving forces of the historical trends identified were technologies and pedagogical approaches. The paper concludes with explanations of how these trends from 1997–2005 have shaped the current focus on Technological Pedagogical Content Knowledge (TPACK) needed for effective current and future eLearning.*

Keywords: *eLearning; ICT; educational computing research; pedagogy; TPACK*

1. Introduction—Why Analyze Educational Computing Research from 1977–2005?

Since the 1970s, researchers began to notice the flexibility and repeatability of computer programs for instruction and this started the era of computer assisted instruction. From those origins more than 30 years ago, educational computing research emerged. We understand that, over time, various terms have been used, such as learning technologies, information and communication technologies for education (ICTE), and digital technologies. Furthermore, the interface between these technologies and learning has been reflected in the use of terms, such as eLearning (electronic learning) and mLearning (mobile learning). For the purposes of this paper, we have defined educational computing research as research that focuses on using information and communication technologies (ICT) to foster innovative pedagogy in terms of improving the effectiveness of learning and teaching.

Arguably, we have witnessed incremental and transformational developments of ICT as technological changes have been dynamic, and disruptive. In particular, the Internet has enabled eLearning, and Pahl [1] noted that technological changes, such as the Internet, have radically changed the way education has been delivered. Few could have imagined, even a decade ago, what technologies we now have available. Despite these developments, a search of the literature revealed that earlier studies had noted that there has been very little study of trends [2,3,4]. The purpose of this study is to analyze educational computing research from the period 1977–2005 to inform understandings of eLearning trends. The paper concludes with explanations of how the educational computing research from 1997–2005 can assist in our understandings of the emergence of the current focus on Technological Pedagogical Content Knowledge (TPACK) [5] needed for effective eLearning.

An obvious question is—Why analyze educational computing trends from 1977–2005? The rationale for this is that a valuable role of research is to identify historical trends and these are replete in educational research literature other than educational computing. Our argument for the selection of the period from 1977 until 2005 is based primarily on the fact that no one has done this. In addition, by presenting this analysis, it can form the basis for a similar analysis for the period 2006–2015. Consequently, this paper, in analyzing 2,694 journal articles from four quality, international journals during that period, provides a platform for understanding where we have come from through an evidence informed approach. The paper then briefly examines the emergence of the Technological Pedagogical Content Knowledge (TPACK) literature, in order to make predictions about the future in relation to educational computing research, policy and practice.

1.1. Selection of the International Educational Computing Journals

In terms of educational computing research, research articles published in academically rigorous, scholarly educational computing journals were identified as being appropriate sources for exploring this issue. The educational computing journals selected were *Computers & Education* [6], *Journal of Computer Assisted Learning* [7], *British Journal of Educational Technology* [8], and *Educational Technology & Society* [9]. The journals were selected as they are considered to be leading educational computing journals, are included in the Web of Science (2013) Social Sciences Citation Index (see http://ip-science.thomsonreuters.com/mjl/publist_ssci.pdf), and they have been published for a considerable period of time. They continue to be ranked in the Top 50 in the Education Subject Category of the Social Sciences in the *SCImago Journal & Country Rank* (SJR) that includes the journals and country scientific indicators developed from the information contained in the Scopus® database. Their rankings are *Computers & Education* (6/50), *Journal of Computer Assisted Learning* (11/50), *British Journal of Educational Technology* (25/50), and *Educational Technology & Society* (47/50). Furthermore, their Impact Factors, provided on their respective journal websites are provided; namely, *Computers & Education* (Impact Factor: 2.775) [6], *Journal of Computer Assisted Learning* (Impact Factor: 1.632) [7], *British Journal of Educational Technology* (Impact Factor: 1.313) [8] and *Educational Technology & Society* (Impact Factor: 1.171) [9]. Consequently, a total of 2,694 journal papers published between the years 1977 to 2005 in these four major educational computing journals were analyzed.

The methodology employed an approach, which focused upon each paper's title, abstract, and keywords. Two educational computing researchers independently coded each paper with an analysis framework to categorize the paper by its research theme compiled from the paper's title, abstract, and keywords. Clustering analysis and multi-dimension scale analysis were performed on the categorized results to explore the research emphasis, research distribution, and the evolutionary trends of the

educational computing research. In addition, as educational computing research is multi-disciplinary and may involve ICT, pedagogy, behavior science, cognition science, and other related fields, research diversity was analyzed through Simpson's diversity index [10] to provide more information on the research emphasis and direction for educational computing researchers, policy makers, and practitioners.

This paper is structured so that the following section describes more fully the analysis framework that was used in this paper categorization process. Subsequently, the research methodology, the main results and discussions drawn from the analyses are presented. The final section provides the concluding remarks and implications of our research, to establish an understanding of the trends identified from 1977–2005 to establish a platform on which future analysis of the literature from 2006–2013 could build our understandings about how those historical trends have informed the current, expanding research, for example, about TPACK [5] and eLearning.

2. The Analysis Framework

Although several researchers [1,11,12] have discussed the definition and content of educational computing research, there was still no clear analysis framework able to be identified that was suitable and scientifically sound for our research purposes. Therefore, we needed to develop an analysis framework before we could proceed to categorize papers. Following a top-down approach, we determined that the analysis framework should have a three-layer hierarchical tree structure. The first-layer attributes, according to the related research, would define the dimensions of this field. The second layer would show the sub-dimensions of the upper layer, while the attributes in the third layer would be the research themes of each sub-dimension. The research themes we provide in the third layer of the analysis framework were compiled from the paper categorizations of the four major educational computing journals that were analyzed. Using this three-layer analysis framework, we are able to effectively categorize a paper into this framework according to its research theme.

The definition of educational computing that was compiled from the studies of Pahl [1], Cloete [11], and Nulden [12]. As outlined earlier, it can be defined as research that focuses on using ICT to foster innovative pedagogy to improve the effectiveness of learning and teaching. Accordingly, educational computing research involves four dimensions, namely, person, ICT, information systems, and pedagogy [1,11,12,13]. These four dimensions form the first layer of the analysis framework.

3. Research Methods

3.1. Data Collection

A total of 2,694 journal papers, published between 1977 and 2005, were collected from *Computers & Education* [6], *Journal of Computer Assisted Learning* [7], *British Journal of Educational Technology* [8], and *Educational Technology & Society* [9]. **Table 3** shows a summary of the collection details and displays that the journal articles were collected from the first issue of each journal until the last issue of the year 2005, except for the *British Journal of Educational Technology* because, during the years 1970 to 1984, papers in that journal mainly focused on how to use broadcasts, and technologies such as television and video recorders, and did not focus on educational computing.

3.2. Coding of Papers

Because each paper's title, abstract, and keywords reflect the research theme of that journal article, two educational computing researchers independently coded each paper, referring to the analysis framework to categorize the paper by its research theme as compiled from the paper's title, abstract and keywords. Each paper was categorized according to no more than five attributes and given a score by each coder for each of these attributes based on the Likert 5-point scale from 'related' to 'strongly related'. Therefore, the categorized result is a 53-dimension tuple (vector) with no more than five places with non-zero values.

To elaborate, each coder entered the coded result of each paper into a computer system. The system compared the two coded results of each paper and reported the discrepancies if coders had attributed different attributes for the same paper or there was an attribute score variance exceeding two scales or the total amount of attribute score variance exceeding four scales. Any discrepancies reported from the system were resolved by a third independent coder, and this process enabled the final data to be determined through the agreement of at least 2 coders. During the coding process, if a new keyword appeared and could not be appropriately categorized into the third layer of the analysis framework, then this keyword was included in the third layer of the analysis framework.

3.3. Data Analysis Methods

Clustering analysis, multi-dimension scale analysis, and research diversity analysis were adopted to analyze the categorized results. Clustering analysis was adopted to explore the research emphasis and distribution of educational computing research. Clustering analysis constructs clusters from data by calculating the distances between data and shows the results in a hierarchical approach. As a result, the analysis can reveal the clusters from data in different view of level.

Multi-dimension scale analysis was employed as each paper's coded result is a tuple with multi-dimensional values. Thus, multi-dimension scale analysis was used to transform them onto a 2-Dimensional (2D) space in order to observe the research trend revealed in the coded results. In sum, multi-dimension scale analysis is a technique to transfer high dimensional data to a lower dimensional space and can still retain the relative distance between the data after the transformation as long as the Kruskal stress coefficient is kept under 0.1 [17]. When the data are represented in lower dimensional space, such as 2D space, it is much easier to observe.

Little attention has been paid to investigating diversity in research in the educational computing discipline, although this is an important way to explore research emphasis and the distribution of multi-discipline research [18,19]. Therefore, in this study we drew upon Simpson's diversity index [10] to measure the research diversity of the educational computing research. Simpson's diversity index, which was originally used to help biologists understand eco-community structures and has been applied to other fields, is obtained by taking the reverse of the sum of square ratio of each species in the community. The value of this index starts at 1 as the lowest possible figure. This figure would represent a community containing only one species. Consequently, the higher the value, then the diversity will be greater. The maximum value is the number of species in the community. In this study, each attribute in the third layer of the analysis framework was taken as a species and, drawing upon Simpson's formula, we can calculate the diversity indexes of each year between 1977 and 2005.

The dramatic increase in the amount of research on web-based learning and the decrease in CAI were the significant changes in types of research. These changes can be attributed to the appearance of the Internet and the World Wide Web around 1992. Educational computing pedagogies embraced the enthusiasm of the possibilities of the Internet to enhance learning performance. The focus of research in educational computing rapidly moved from CAI to web-based learning from then, and formed the

major turning point from Trend A to Trend B. In addition, through the Internet, computer mediated communication systems, which provide the opportunities for learning at anytime and anywhere, became an increasing research issue in application dimensions throughout the research disseminated in the selected journals. Multimedia research kept increasing, but the research context moved toward the web and hypermedia. In addition to multimedia research, it is to be noted that research in mobile communications also emerged as being increasingly the focus of research interest. The web also fosters possibilities for pedagogical approaches, adaptive course website design, collaborative learning, and problem-based learning, and these areas increased in terms of research publications. At the same time, the trend in relation to research about the person dimension, cognition type and learning community saw increased research activity.

In addition to the above analyses from the results shown in **Table 5** and **Table 6**, further comparisons of the differences between Trend A and Trend B in the four different dimensions, namely, application, ICT, pedagogy and person, three important trends can be noted. Firstly, personalization and collaborative learning of constructivism pedagogy through web technologies emerged into the mainstream, replacing CAI in mastery learning pedagogy. Secondly, new emerging research in the application dimension reflected the growing understanding about the interface and relationships between ICT developments and pedagogical implications for teaching and learning. These two areas—new and emerging ICT and pedagogy needs—became the two major driving forces in educational computing research. We argue that this also became closely related to ICT implementation challenges in translating the research to policy and, importantly, to practice. Thirdly, in observing the ICT and pedagogies involved in applications and contrasting the development of pedagogical paradigms to the ICT developments, as shown in **Table 7**, we suggest that, although both ICT and pedagogy paradigms are the two major driving forces in educational computing, pedagogy paradigms lead the application approach to ICT in the educational computing field. In other words, the relationship between these two driving forces is that ICT carries out pedagogical functions, and serves as a catalyst and enabler for the effective application of the education models.

5. Conclusions

The technological changes, which can be mapped back in the educational computing literature as far as 1977, have been unprecedented in history. The accompanying implications for education have been considerable. This paper identified three major waves evident in the educational computing research in four prominent international journals throughout the period from 1977 until 2005. Consequently, this paper has provided the platform upon which subsequent research has focused, namely, ICT and pedagogy, with the earlier formative research catalysts being the personal computer (first wave), and the Internet (second wave). The contribution that this paper makes is an evidence-informed identification of the major historical trends in the educational computing research, which have led to the current research interests, for example, in TPACK, online learning, eLearning, and social media. The analysis also acknowledged the identification of the diversity of educational computing research, and suggested that further research, for example, between 2006-present which could build upon this important analysis, can illuminate the relationships between educational computing research, policy, and practice.

To conclude, the analysis has shown that technological innovation provides a catalyst for research, which provides new knowledge about the potential for those innovations to enhance teaching and learning. Appropriate research evidence informed policy responses and strategies are needed to enable enhanced learning and teaching practices. Currently, the driving forces seem to be a continuation of the

third wave focusing on technologies and pedagogies, which this study identified as appearing as early as 2001. Moreover, the current focus on personalized learning and use of social media appear to have their origins during that period. The expanding TPACK literature base and research interest seems to be a continuation and strengthening of the third wave. A key message is that this analysis of the historical trends helps us to understand the major historical trends upon which further analysis of subsequent research can be undertaken and the relations between research, policy, and practice can be interpreted.

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