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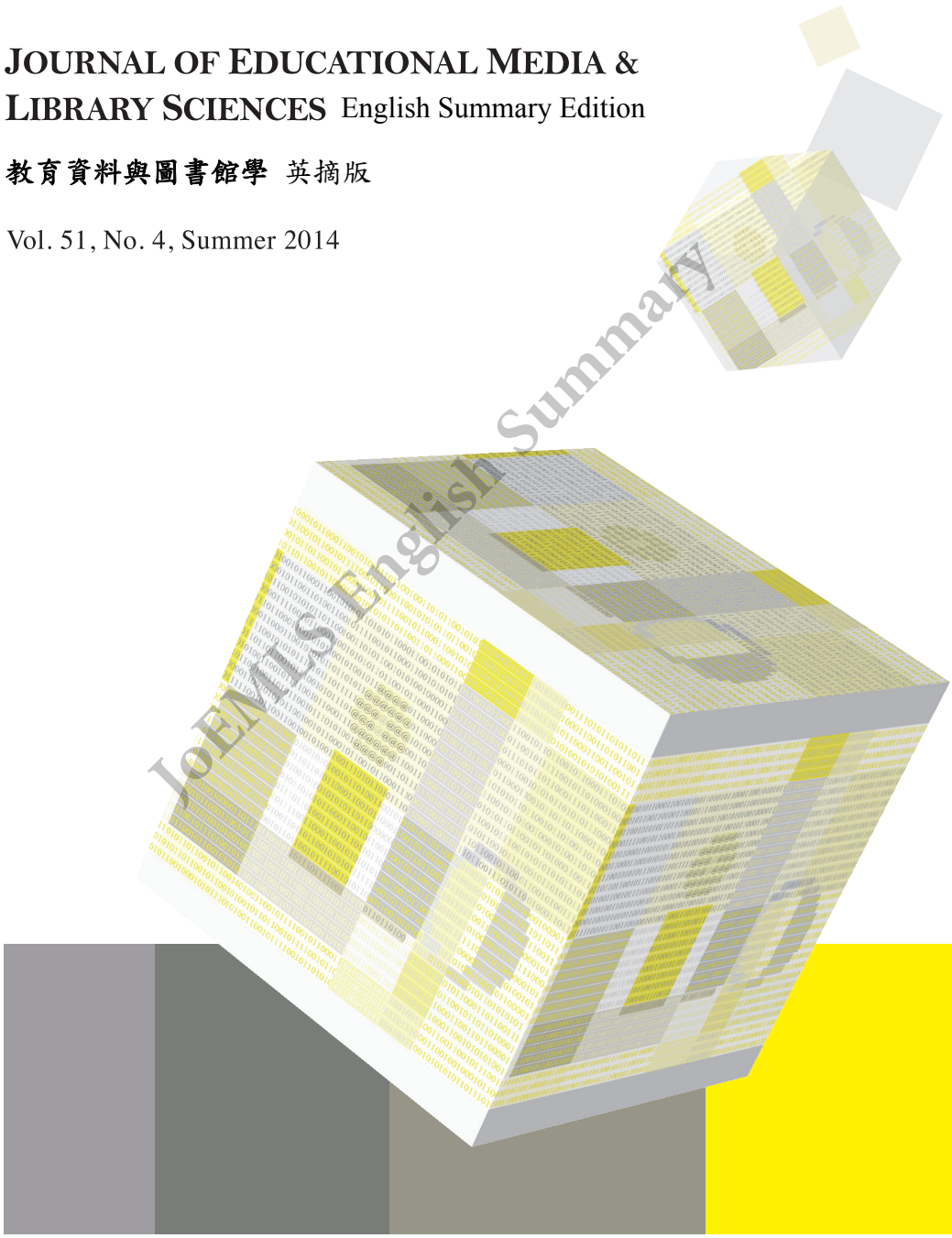

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教育資料與圖書館學 JOURNAL OF EDUCATIONAL MEDIA & LIBRARY SCIENCES Vol. 51, No.4, Summer 2014

教育資料與圖書館學，始於1970年3月創刊之**教育資料科學月刊**，其間於1980年9月更名為**教育資料科學**，改以季刊發行。自1982年9月起易今名，而仍為季刊，每年秋(10月)、冬(翌年1月)、春(4月)與夏季(7月)各出刊一期，合為一卷。現由淡江大學出版中心出版，淡江大學資訊與圖書館學系和覺生紀念圖書館合作策劃編輯。本刊為國際學術期刊，2008年獲國科會學術期刊評比為第一級，並廣為海內外知名資料庫所收錄(如下英文所列)。

The JOURNAL OF EDUCATIONAL MEDIA & LIBRARY SCIENCES *(JoEMLS)*, published by the Tamkang University Press and co-published with the Department of Information & Library Science (DILS) and Chueh Sheng Memorial Library, was formerly the ***Bulletin of Educational Media Science*** (March 1970 – June 1980) and the ***Journal of Educational Media Science*** (September 1980 – June 1982). The *JoEMLS* has been a quarterly as well as a new title since September 1982, appearing in Fall, Winter, Spring and Summer issues.

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教育資料與圖書館學 封面意義：躍升於紙本印象上的數位與網路化圖書資訊圖騰。
The cover design of ***JoEMLS*** signifies:
L (Librarianship); **I** (Information Technology); **B** (Bibliophile and the Book trade)

教育資料與圖書館學
JOURNAL OF EDUCATIONAL MEDIA & LIBRARY SCIENCES

JoEMLS 編輯政策

本刊係採開放存取（Open Access）與商業資料庫付費途徑，雙軌發行之國際學術期刊，兼具電子版與紙本之平行出版模式。本刊除秉持學術規範與同儕評閱精神外，亦積極邁向InfoLibrary寓意之學域整合與資訊數位化理念，以反映當代圖書資訊學研究趨勢、圖書館典藏內容與應用服務為本；且以探討國內外相關學術領域之理論與實務發展，包括圖書館學、資訊科學與科技、書業與出版研究等，並旁及符合圖書資訊應用發展之教學科技與資訊傳播論述。

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JoEMLS Editorial Policy

The *JoEMLS* is an Open Access (OA) Dual, double-blind reviewed and international scholarly journal dedicated to making accessible the results of research across a wide range of Information & Library-related disciplines. The *JoEMLS* invites manuscripts for a professional information & library audience that report empirical, historical, and philosophical research with implications for librarianship or that explore theoretical and practical aspects of the field. Peer-reviewed articles are devoted to studies regarding the field of library science, information science and IT, the book trade and publishing. Subjects on instructional technology and information communication, pertaining to librarianship are also appreciated. The *JoEMLS* encourages interdisciplinary authorship because, although library science is a distinct discipline, it is in the mainstream of information science leading to the future of **InfoLibrary**.

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(1) authors can archive both preprint and postprint version, the latter must be on a non-commercial base;
(2) publisher's PDF version is the most recommend if self-archiving for postprint is applicable; and
(3) published source must be acknowledged with citation.

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EDITORIAL

In Memory of Prof. Chang C. Lee

Former Chief English Editor of our *Journal of Educational Media and Library Sciences (JoEMLS)*, Professor Chang C. Lee, passed away at Florida, USA, on 31 May 2014, aged 80. A memorial service was held in June for local overseas Chinese to attend. Professor Lee had been working on library administration at University of Central Florida, and before Volume 40 Issue 4, 2003, he had been acting as Chief English Editor of our journal for almost twenty years, assisting in calling for international papers, reviewing manuscripts and undertaking liaison jobs for publishing. Professor Lee had worked his best for calling for American manuscripts and promoting academic communications. He made a great contribution not only to the steady development of our journal, but also to our goal of becoming an international journal.

Professor Lee graduated from Department of Journalism, National Cheng-Chi University, Taiwan, and arrived at Florida State University in 1967 for graduate studies. He received a master degree on Library Science and a doctoral degree on Higher Education. During his more than 40-year career in USA, he had been taking good care of oversea students from Taiwan and China. During his decade-long career, he had worked as professor and library director at several universities, actively participated and lead in local overseas Chinese community activities and services, and was elected as the President of Chinese-American Librarians Association (CALA) in 1979. Professor Lee had ever returned to Taiwan for one year, working as Visiting Scholar at Department of Educational Media Science, Tamkang University, as well as at National Cheng-Chi University. Even after he retired and left the position of our Chief English Editor, he still offered a great help for the successor Chief Editor to take over the job smoothly. His unreserved caring and contribution, as well as his elderly kindly demeanor, will be missed forever.

In this Volume 51 Issue 4, four articles were published from twelve, and eight were rejected, with a rejection rate of 66.67%. Nine articles were still at their review stage. The *JoEMLS* will adopt *APA, Chicago (Turabian) and Romanization of Referencing Styles for Chinese Academic Writing*, published by Tamkang University Press, for facilitating the editing of translated bibliographies. The book with scientific theories and practical regulations addressed inside is expected to be a great help for Taiwan's scholars in humanities and social sciences, academic journal editors, and academic database providers.

Four articles published in this issue include "Effects of Online Student Question-Generation with Multiple Procedural Guides on Elementary Students' Use of Cognitive Strategies and Academic Achievement" by Fu-Yun Yu and Yi-Shiuan Lai, "The Effects of Inquiry-Based Integrated Information Literacy Instruction: Four-Year Trends" by Lin Ching Chen, Ren-De Yan, and Tsai-Wei Huang, "Analyses of Research Topics in the Field of Informetrics Based on the Method of Topic Modeling" by Sung-Chien Lin, and "Review of the Development of Learning Analytics Applied in College-Level Institutes" by Ken-Zen Chen. Thanks for your manuscript submission, understanding and patience, for us to be able to admire outstanding academic demeanor.

Jeong-Yeou Chiu
JoEMLS Chief Editor

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Research Article

Analyses of Research Topics in the Field of Informetrics Based on the Method of Topic Modeling

Sung-Chien Lin

Abstract

In this study, we used the approach of topic modeling to uncover the possible structure of research topics in the field of Informetrics, to explore the distribution of the topics over years, and to compare the core journals. In order to infer the structure of the topics in the field, the data of the papers published in the Journal of Informetrics and Scientometrics during 2007 to 2013 are retrieved from the database of the Web of Science as input of the approach of topic modeling. The results of this study show that when the number of topics was set to 10, the topic model has the smallest perplexity. Although data scopes and analysis methods are different to previous studies, the generating topics of this study are consistent with those results produced by analyses of experts. Empirical case studies and measurements of bibliometric indicators were concerned important in every year during the whole analytic period, and the field was increasing stability. Both the two core journals broadly paid more attention to all of the topics in the field of Informetrics. The Journal of Informetrics put particular emphasis on construction and applications of bibliometric indicators and Scientometrics focused on the evaluation and the factors of productivity of countries, institutions, domains, and journals.

Keywords: *Analyses of research topics; Informetrics; Topic modeling*

SUMMARY

Introduction

This study used the method of topic modeling to analyze important research topics in the field of Informetrics and the development in recent years. Using texts of a collection of documents as input and the topic modeling method, we generated sets of statistical parameters consisting of a set of possible topics as well as topic mixtures for all documents in the collection. In this study, the texts of papers published from 2007 to 2013 in *Scientometrics* and *Journal of Informetrics*, which are core journals in the field of Informetrics, were used as data source. The topic model resulted from the study was provided for analysis of the examined field. This study investigated the following problems:

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1. Identify important topics studied in the field from 2007 to 2013. Discuss the feasibility of applying the topic modeling method to this kind of studies;

2. Understand the distributions and developments of topics in the field of Informetrics;

3. Compare the distributions and developments of topics in *Scientometrics* and *Journal of Informetrics*.

Methods

The method of topic modeling which describes the word generation process of text in a document, is based on a statistical model (Blei, Ng, & Jordan, 2003; Griffiths & Steyvers, 2004). It assumes that every word w in a document d is generated by a topic z, which is sampled from the topic probabilistic mixture θ_d of the document d, as well as the corresponding word probabilistic mixture ϕ_z of the topic z, which can be used to select a word from a vocabulary. Furthermore, to describe the possible word generation process in a document collection, we need two sets of parameters: the first set of parameters (θ_d) is the probability determining the selection of topics for each document. The second set (ϕ_k) determines which word will occur when a specific topic is chosen. Several algorithms have been proposed to infer those unknown parameters of topic models. The parameter inference algorithm used in this study is Gibbs sampling proposed by Griffiths & Steyvers (2004).

To infer parameters of topic models, texts were collected and prepared first before being applied with the algorithm. In this study, data of the papers were retrieved from the citation database WoS (Web of Science). The search criteria were 1) paper type was "Article", 2) publication year was from 2007 to 2013, and 3) the source was either "*Scientometrics*" or "*Journal of Informetrics*". Texts in the fields TI (title) and AB (abstract) of a paper were merged into on piece of text for topic modeling. All punctuations, numbers and stop words in the texts were removed and all words in the remaining texts were transformed into lower case using the functions provided by the R statistical analysis software package "tm" (Meyer, Hornik, & Feinerer, 2008). We also counted the occurrences of all word tokens in the document collection, and the common words (appearing in more than 5% of the documents) and rare words (appearing in less than 1% of the documents) were deleted to reduce computational resources. Finally, the frequency counts of word tokens occurring in each document were used as input for another R package "topicmodels" (Grün & Hornik, 2011) to infer the statistical parameters of topic models.

In terms of interpreting the inferred topic model, we defined "core words" and "typical papers" for each topic in this study. The core words of a topic were

those words with the highest probability of this topic. Typical papers for a topic were those papers which the examined topic had the highest probability among all topics. When the inference of topic model for the document collection completed, both the word probability for each topic, ϕ_k, and the topic probability for each document, θ_d , were sorted in descending order. The core words and the typical papers for each topic were obtained at this point. In this study, 10 core words and 10 typical papers were selected for each topic.

The probability of topics in a set of papers can be calculated by averaging the probabilities of the corresponding topics in all the papers in the set. For example, to analyze topics occurred in the field of Informetrics from 2007 to 2013, the average of topic probabilities of all papers in the entire collection was used. If a specific topic had the highest average probability in the entire collection, the topic could then be considered as the most important one in the field. Therefore, we would rank all topics occurred in the whole field by comparing the average probabilities in the total collection. In the similar way, we could calculate the probability distributions of topics in a certain journal or in publications from a certain year by averaging the topic distributions of all papers published in the journal or in the certain year.

The disparity of two topic distributions in difference paper collections can be measured with the symmetric Kullback-Leibler divergence (Rzeszutek, Androutsos, & Kyan, 2010). When the two distributions are equal, the measure of symmetric Kullback-Leibler divergence between them is 0. If there are big differences between the two distributions, the measure will be larger than 0.

Results

In this study, a total of 1,755 papers were selected, including 1,374 papers from *Scientometrics* and 381 papers from *Journal of Informetrics*. The texts (the titles and abstracts of the papers) were prepared and 1,147 word tokens were extracted. Estimating through the leave-one-out method, the minimal average perplexity is 683.46 while the number of topics was assigned to 10. Therefore, we set the number of topics to 10 in this study. The followings are these 10 inferred topics:

- Topic 1: studies of technology innovation and knowledge communication networks based on the techniques of patent analysis;
- Topic 2: theoretic studies and applications of the h-type indices;
- Topic 3: growth and trends of academic productivity;
- Topic 4: empirical studies related to journal impact factor;
- Topic 5: performance evaluation and ranking for research institutions, including productivity and quality;

- Topic 6: issues of scholar publishing, such as paper review;
- Topic 7: measures and applications of bibliometric indicators;
- Topic 8: studies of scientific collaboration;
- Topic 9: influence of demography and characteristics of scientists on their performance and the social relationships among scientists;
- Topic 10: domain analysis, including the studies of topic identification and scientific maps.

Some findings from analysis of the resulting topic model show in follows:

The topic distributed in the entire field was fairly balanced from 2007 to 2013. The probabilities of all topics in the entire collection were almost the same. However, Topic 1 and Topic 4 were slightly larger than the others.

The topic distribution in 2008 was different from those measured by the symmetric Kullback-Leibler divergence in other year. It was because the probabilities of Topic 1 and Topic 2 in 2008 were significantly different from those in other years.

The topic distributions in the last 3 years were very similar and they were different from the topic distributions in the first 4 years. The changes of Topic 3, Topic 6 and Topic 7 contributed to the different topic distributions. The probability distribution of the Topic 3 in the earlier 3 years was about 0.11, but in later 4 years it was only 0.10 or less. There was a clear downward trend. Conversely, the probability distributions of the Topic 6 and the Topic 7 were less than 0.09 and 0.10 in the first 4 years and were raised to 0.10 and 0.11 in the later years.

Journal of Informetrics and *Scientometrics* both published various topics in the field of Informetrics. But the *Scientometrics* published a wider range of topics. *Scientometrics* had slightly higher probability distributions on Topic 1 and Topic 8 and it also preferred Topic 3, Topic 4 and Topic 5. The *Journal of Informetrics* had obviously higher probability distributions on Topic 2, Topic 7, Topic 4, and Topic 10.

Discussion

According to the results, this study makes the following conclusions:

1. Although the data scope and the methods used in the analyses are not the same, the results of this study are still consistent with those of previous studies. For example, Topic 3 can be assigned into the class “bibliometric theory, mathematical models and formalisation of bibliometric laws” provided by Schoepflin & Glänzel (2001), and Topic 6 and 9 are parts of “sociological approach to bibliometrics”.

2. Each topic in the field of Informetrics has received considerable attentions,

especially practice-based research such as the applications of patent analysis and journal impact factor.

3. Because there is only little difference between the topic distributions in last three years, this field was more stable than before.

4. Through comparing the topic distributions of the two core journals, we can observe that these journals published all topics in the field of Informetrics. However, *Journal of Informetrics* has special focus on the construction and applications of various bibliometric indicators. *Scientometrics* has put attention on the evaluation of academic productivity of countries, institutions, fields and journals.

ROMANIZED & TRANSLATED REFERENCE FOR ORIGINAL TEXT

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Effects of Online Student Question-Generation with Multiple Procedural Guides for Elementary Students' Use of Cognitive Strategies and Academic Achievement

Review Article

Fu-Yun Yu[a*] Yi-Shiuan Lai[b]

Abstract

Student question-generation (SQG) procedural guides differ in terms of level of concreteness, demands on cognitive skills and appropriateness for respective instructional units. Because existing studies exclusively examine the effects of individual guides, this study was aimed at an investigation of the effects of online SQG with multiple guides intended to promote elementary students' use of cognitive strategies and to improve academic performance while learning Chinese and science. A quasi-experimental research method and an online learning system with dynamic scaffolding designs were adopted to support student learning of Chinese and science via the SQG approach. Two fifth-grade classes (N=56) participated for eight weeks. Twice per week, in accordance with the instructors' schedules, students engaged in online SQG or self-study activities in their randomly assigned groups. The results of the analysis of covariance indicated significant differences between the two treatment groups in their use of cognitive strategies while learning Chinese and science, with students in the SQG group scoring significantly higher than those in the comparison group. However, academic achievement between the two groups did not differ significantly. Suggestions for instructional implementations and future studies are provided.

Keywords: *Academic achievement; Online learning system; Student question-generation; Use of cognitive strategies*

SUMMARY

Introduction

The traditional transmission teaching mode is no longer sufficient or adequate to prepare citizens to be equipped with 21st century skills (e.g., creative thinking, critical thinking, communication and collaboration, and complex problem-solving ability). Determining a method by which to transform classroom environments by integrating innovative instructional strategies that support active learning and the cultivation of higher-order thinking skills, deep information

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processing and knowledge construction on the learner's part has become an important educational goal worldwide.

Student-generated questions (hereafter called SQG), in alignment with contemporary educational theories including information processing theory and constructivism, is a notable cognitive and meta-cognitive strategy. Rather than simply subsuming what has been delivered by the instructor, when engaged in SQG, students will be more likely to act as active processors that select, organize, store, integrate and retrieve information that mobilizes generative learning and leads to productive outcomes (Yu & Hung, 2006; Yu & Liu, 2005b).

The learning benefits of SQG have been well-documented, and the empirical studies on SQG have generally been positive (Yu, 2012). Overall, the accumulated evidence from empirical studies since the 1960s provides a solid basis to support the teaching and inclusion of SQG to enhance comprehension, academic achievement, motivation, question-generation abilities, the use of cognitive strategies, problem-solving abilities and attitudes toward the subject matter being studied (Barak, & Rafaeli, 2004; Brown & Walter, 2005; Chin & Brown, 2002; Dori & Herscovitz, 1999; Perez, 1985; Toluk-Uçar, 2009; Yeh & Lai, 2012; Yu & Hung, 2006; Yu & Liu, 2005b). Despite the predominately positive effects of SQG, existing studies resort to single procedural guide to support SQG.

Currently, there are several procedural guides in existence. Because each guide differs in regard to its level of concreteness, specifics of focus, demands on cognitive skills and ease of learning and use on the learner's part (Rosenshine, Meister, & Chapman, 1996), rather than resorting to one guide, a combinational approach in accordance with the study content would potentially be a viable and situation-sensitive instructional approach. In an attempt to establish empirical evidence of this, the effects of online SQG with multiple guides for elementary students' use of cognitive strategies and academic performance are the focus of this study.

Research Methods

A quasi-experimental research method was adopted. Students from two fifth-grade classes (N = 56) were invited to participate and were randomly assigned to two treatment groups-one being the experimental group (i.e., SQG with multiple guides) and the other the control group (i.e., traditional self-study group).

This study took place in the context of Chinese and science instruction. Prior to the commencement of this study, data on students' use of cognitive strategies and academic performance in both Chinese and science were collected. To ensure that the integrated multiple guides were suitable for the targeted audience and

subject matter, expert evaluation with a group of six subject matter experts was conducted. As a result, a total of five procedural guides including signal word (Rosenshine et al., 1996), main ideas (Dreher & Gambrell, 1985; Ritchie, 1985), question types (Raphael & Pearson, 1985), the answer is (Stoyanova & Ellerton, 1996) and what if / what if not (Brown & Walter, 2005) were selected for science SQG, whereas signal word, main ideas, question types, the answer is and story grammar (Nolte & Singer, 1985; Short & Ryan, 1984) were chosen for Chinese SQG. Finally, to equip students in the experimental group with essential SQG knowledge and skills, a training session was held. During the training session, quality criteria associated with SQG and the operational procedures for the adopted system were explained, followed up by student hands-on spaced practice activities.

Afterwards, twice per week (one for Chinese and the other for science) for eight consecutive weeks, students assigned to the experimental and control groups engaged in online SQG and self-study activities, respectively, in accordance with instructors' weekly lesson plans in 35-minute instructional sessions. A SQG online system with dynamic scaffolding designs was adopted for the experimental group's use. After the study, the "Cognitive Strategies Use Scale" (18 items, 6-point Likert scale) with good validity and reliability was disseminated for completion by the students on an individual basis in order to collect data on the use of rehearsal, elaboration and organization strategies while learning Chinese and science. Finally, the students' academic performance in the school-wide exams in Chinese and science administered at the end of the study was used to assess their learning of the topics covered during the study.

Results and Discussion

The results of the analysis of covariance revealed significant differences between the two treatment groups in the use of cognitive strategies while learning Chinese, $F\ (1, 53) = 14.49$, $p < .05$, and science, $F\ (1, 53) = 19.70$, $p < .05$ with students in the SQG group scoring significantly higher than those of the control group. However, academic achievement between the two groups did not differ significantly for either Chinese, $F\ (1, 53) = .53$, $p > .05$, or science, $F\ (1, 53) = 1.35$, $p > .05$.

The significantly higher frequent activation of cognitive strategies highlighted the beneficial effects of SQG with multiple guides to induce students to engage more in rehearsal, organization and elaboration, as compared to the self-study traditional approach. The current study confirmed the research hypothesis that students with explicit procedural guides during SQG including signal words, story grammar categories, main ideas and question types seemed to mobilize

versatile cognitive strategies such as reading and re-reading, copying, association, rephrasing, relating to one's own experience or prior study content, pinpointing important concepts / keywords / sentences by underlining or marking, rearranging material, and so on, to help organize / re-organize, interconnect and present the material under study during the learning process. On the other hand, even though students assigned to the SQG approach performed better in both Chinese and science academic achievement as compared to those in the self-study group, and even though it is implied by cognitivists that deep processing, such as rehearsal, elaboration and organization help consolidate knowledge better and longer (Reigeluth, 1983; Weinstein, Husman, & Dierking, 2000), the differences did not reach statistical significance.

Conclusions

The findings of this study substantiated the positive effects of SQG with multiple guides for the promotion of the use of cognitive strategy when students interact with learning material. The results obtained from the current study helped to extend the empirical basis of SQG with a single guide. As Rosenshine et al. (1996) argued, each of the procedural prompts addressed in this study was different in regard to its level of concreteness, specifics of focus, demands on cognitive skills, and ease of learning and use on the part of the learner. As such, rather than resorting to one guide during SQG, based on the current findings, it is suggested that instructors may consider adopting a combinational approach, that is, SQG with multiple procedural guides in accordance with the study content, in order to achieve sensitive and adaptive support that will enhance the development of the use of cognitive strategy in students.

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Research Article

The Effects of Inquiry-Based Integrated Information Literacy Instruction: Four-Year Trends

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Abstract

The purpose of this study was to examine the effects of four-year integrated information literacy instruction via a framework of inquiry-based learning on elementary students' memory and comprehension. Moderating factors of students' academic achievement was another focus of this study. The subjects were 72 students who have participated in this study since they entered an elementary school in Chiayi district. This elementary school adopted the integrated information literacy instruction, designed by the researchers and elementary school teachers, and integrated it into various subject matters via a framework of inquiry-based learning, such as Super3 and Big6 models. A series of inquiry-based integrated information literacy instruction has been implemented since the second semester of the subjects' first grade. A total of seven inquiry learning projects has been implemented from grade one through grade four. Fourteen instruments were used as pretests and posttests to assess students' factual recall and conceptual understanding of subject contents in different projects. The results showed that inquiry-based integrated information literacy instruction could help students memorize facts and comprehend concepts of subject contents. Regardless of academic achievements, if students would like to devote their efforts to inquiry processes, their memory and comprehension of subject contents improved effectively. However, students of low-academic achievement might need more time to be familiar with the inquiry-based learning strategy.

Keywords: *Inquiry-based learning; Information literacy; Memory; Comprehension; Academic achievement; Longitudinal study*

SUMMARY

Introduction

Information literacy is the ability to recognize, locate, evaluate, use and create the information needed effectively (American Association of School Librarians & Association for Educational Communication and Technology [AASL

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& AECT], 1998; Andretta, 2005). Many studies find that information literacy instruction should be integrated across the contexts of school curriculum and through inquiry-based learning (Chen, 2013; Eisenberg, Lower, & Spitzer, 2004; Kuhlthau, Maniotes, & Caspari, 2007; Rockman, 2004). Inquiry-based learning results better knowledge application and reasoning skills. However it is not as effective in basic or factual knowledge acquisition than traditional curriculum does (Strobel & Barneveld, 2009; Wolf & Eraser, 2008). Studies also find that students of different academic achievement may perform differently in integrated information literacy instruction (Chu, 2009; Cuevas, Lee, Hart, & Deaktor, 2005; Todd, 1995). However, the abovementioned studies are mostly conducted in a short term. Few research investigates the effects of information literacy instruction in a longer period of time.

The purpose of this study is to investigate the effects of four-year integrated information literacy instruction on elementary students' memory retention and comprehension of subject contents through inquiry-based learning. Moderating factor of students' academic achievement is another focus of this study.

Methods

The researchers collaborated with classroom teachers and school librarians to develop the inquiry-based information literacy curriculum and integrated it into various subject matters year by year. All participants received two pretests, the integrated instruction, and two posttests each semester since the first grade. The tests were designed to test participants' memory retention and comprehension of the instructional contents respectively.

The study was conducted at Chiachia Elementary School (a pseudonym), which was in an urban area in southern Taiwan. Since 2005, this school has adopted the information literacy curriculum and integrated it into various subject matters. The curriculum was taught once a week from the first grade to the second grade and twice the third grade through the sixth grade. Each class period was forty minutes.

The participants were 72 students (41 boys and 31 girls), who have enrolled in this study since they were first graders entering Chiachia Elementary School. According to their performance in five subject areas (Chinese, mathematics, life, science, and social studies) for the past four years, participants were divided into three groups of low-, medium-, and high-academic achievement students.

The information literacy curriculum was integrated into subject matters via an inquiry-learning framework, such as Super3 and Big6 models. A total of seven inquiry projects had been carried out in each semester since the second semester of the first grade. The inquiry themes involved relevant units in subject matters so

that students could apply the information literacy skills in real situations.

Seven instruments of memory retention were used as pretests and posttests to assess students' recall of factual knowledge. All of the questions were multiple-choice. The KR-20 reliability coefficients of the seven memory tests were from .693~.954. Their discrimination coefficients ranged from .366 to .675.

Seven instruments of comprehension were used to assess students' understanding and applications of the subject contents in different projects. There were different types of questions in the instruments, such as multiple-choice, fill-in-the-blank, essay, drawing, etc.. The Cronbach's α reliability coefficients of the seven tests were from .710~.785. The discrimination coefficients of the seven tests ranged from .217 to .600.

The data source for this study was the scores from the instruments. Data were collected over 4 years from 7 inquiry projects and analyzed by SPSS 20. Paired sample *t* tests were conducted to measure students' improvements in memory retention and comprehension between pretests and posttests. Due to the item numbers were different among the seven instruments of memory retention and comprehension, the test scores could not be compared directly. Therefore, the test scores of memory retention and comprehension were transformed into standard T scores and pair-wise comparisons (i.e., low-achieving group vs. medium-achieving group, low-achieving group vs. high-achieving group) were used to obtain the difference between them. The effect sizes (*Cohen's d*) were calculated in order to determine the relative magnitudes of experimental treatments and to judge the practical meaningfulness of the results derived. At last, the effect size values were plotted out in a run chat which displayed four-year trend among students of different academic achievements.

Results

1. Students' Memory Retention in the Inquiry-Based Learning Projects

The results of paired-sample *t* tests for seven memory retention pretests and posttests in the inquiry-based projects were calculated. Except for "Investigation of Life on Campus" in the first grade, all six obtained t values were all significant. The results might be caused by the reason that the participants learned the inquiry-based information literacy curriculum for the first time. In all, students performed well in memorizing factual knowledge in subject-matter contents.

To further understand the learning performance differences among students of different academic achievements, paired *t* tests for memory retention pretests and posttests on seven inquiry projects were conducted. According to Cohen's effect size index (1988), regardless of low-, medium- and high-achieving students, the numbers of large effect size were more than the numbers of medium and

small effect size. It implied that the instructional interventions could improve effectively students' memory retention, regardless of their academic achievements.

We further examined the trends of effect sizes across four years by comparing the posttest scores between two groups. All the three trends of effect sizes seemed to increase in the second grade and then decrease from the third grade thru the fourth grade. This meant that the discrepancies of memory capability between students of lower level and higher level of academic achievements were first enlarged but shrunk later after integrating information literacy into the inquiry projects during the four years. In other words, the lower levels of academic-achieving students may be not familiar with memory learning in the information literacy instructions at the beginning, but they can progress and reach to the level of high academic-achieving students in one or two years later. The medium-achieving students reached to level of the high-achieving students in the third grade, while the low-achieving students drew near the memorization levels of their medium- and high-achieving peers in the fourth grade.

2. Students' Comprehension in the Inquiry-Based Learning Projects

The obtained t values of paired-sample *t* tests for seven comprehension pretests and posttests were all significant, which meant all students improved in comprehending subject contents. Regardless of low-, medium- and high-achieving students, the numbers of large effect size were more than the numbers of medium and small effect size. The medium achieving students progressed with the highest level of improvement.

The comprehension trends of effect sizes across the four years between the two groups were similar to the memory retention trends. All the three trends of effect sizes seemed to increase in the second grade and then decrease from the third grade to the fourth grade. The discrepancies of comprehension capability between lower and higher levels of academic-achieving students were first enlarged but shrunk later after integrating information literacy into the inquiry projects during the four years. The scenario of progression on comprehension ability was specially manifested for the medium-achieving students to reach to level of the high-achieving students. However, the effect sizes of L-M and L-H in the fourth grade still are medium magnitude, which have practical significance. Thus, it seems that low-achieving students may need more time to get familiar with inquiry-based learning strategy.

Conclusion

In the four-year integrated information literacy instruction, students performed well in memorizing and comprehending subject contents. Therefore, integrating information literacy into inquiry learning can help elementary students

memorize factual knowledge, comprehend subject concepts and apply in new situations. These findings are similar to the results found by previous researchers (Chen, 2012; Loyens & Rikers, 2011). In fact, in the four-year integrated information literacy instruction, the selection of inquiry topics and the design of instructional activities were both completed via constant dialogues among researchers, classroom teachers and librarians. Thus, the integrated instruction matched the elements for building inquiry motivation proposed by Thomas, Crow and Franklin (2011). The elements included choice of topics, ties between course contents and research topics, explicit goals and evaluation criteria, etc..

With respect to academic achievements, regardless of low-, medium- and high- achieving students, if students would like to devote their efforts to inquiry processes, their factual memory and conceptual understanding of subject contents improved effectively. Low- achieving students were still behind medium- and high- achieving ones in comprehension learning. The results confirms Hung's claim (2010) that students of low-academic achievement might need more time to be familiar with inquiry-based learning strategy.

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Review Article

Review of the Development of Learning Analytics Applied in College-Level Institutes

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Abstract

This article focuses on the recent development of Learning Analytics using higher education institutional big-data. It addresses current state of Learning Analytics, creates a shared understanding, and clarifies misconceptions about the field. This article also reviews prominent examples from peer institutions that are conducting analytics, identifies their data and methodological framework, and comments on market vendors and non-for-profit initiatives. Finally, it suggests an implementation agenda for potential institutions and their stakeholders by drafting necessary preparations and creating iterative implementation flows.

Keywords: *Big-Data; Educational data mining; Learning analytics*

SUMMARY

Introduction

Student persistence is the key to integrate students academically into the University (Arnold & Pistilli, 2012) and faculty needs information about learners to help them achieve academic success. The rapid development of the analytics has gathered high interests among government sectors, accreditation agencies, institutions, and educators in higher education (Dringus, 2012). The purpose of this review is to document the development of and the current state of Learning Analytics in higher education. By publishing this article in a Taiwan-based scholarly journal, the author wants to create understanding and discussion of Learning Analytics in Chinese-speaking scholarly communities. Moreover, the author also suggests a blueprint for higher education institutions in Taiwan that may be of interest in implementing Learning Analytics in institutional research practices.

The Development of Data-Driven Analytics in Higher Education

Analytics is an activity to "use of mathematical and algorithmic methods to describe part of the real world, and reducing real-world complexity to a more

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easily understandable form" (van Harmelen, 2012, p. 3). In the past, most learning processes were not trackable. But nowadays, huge amounts of trackable data is available from data storages such as the learning management systems (LMS). For instance, much e-learning research relied on the student perception data (e.g. surveys and self-evaluations) for decades and might not provide an accurate picture of learning (Phillips, Maor, Cumming-Potvin, Roberts, Herrington, Preston, & Moore, 2011). Nowadays, online students' learning activities are mostly tracked in the LMS when they access online and understanding their process of learning becomes possible. John Easton, the Director of the Institute of Education Science at the U.S. Department of Education, has remarked that using data as the mean to improve school and student learning is occurring (Mandinach & Gummer, 2013). *The 2013 NMC Horizon Report* also signals that the technology adoption of Learning Analytics should happen within two to three years (Johnson et al., 2013). Business Analytics and Educational Data Mining are two roots that lead to the development of Learning Analytics.

Root 1: Business analytics

The Web Analytic tools such as Google Analytics and Amazon recommendation system have provided successful stories of leveraging the power of analytics. Oblinger (2012a, p. 11) then explained that the business application of analytics is to "help run the business of higher education institution". Business Analytics is interested in the customer preferences and ends up with the dichotomized conclusions of purchasing behaviors (whether to buy or not). Hence and Cooper (2012a, 2012b) commented that even though Business Analytics has had advantages in dashboards, and may provide valuable suggestions to admission and academic advising, it does not effectively address insights to college students' learning processes.

Root 2: Educational data mining

Educational Data Mining (EDM) is an applied field that adopts statistical data mining algorithms to solve educational problems. Using a variety of techniques (e.g., decision tree, rule induction, artificial neural network, Bayesian learning, logic programming, etc.), the previously unknown data patterns are discovered without implying an established theoretical framework or a statistical model (Ferguson, 2012). Using assumption-free Big-Data, EDM directly tests learning theories to inform educational practices (MacNeill, 2012). Using EDM techniques, Learning Analytics is able to rely on the information culled from various data sources to determine the status of academic progress, recognize potential issues and intervention points, and predict future performance (Mattingly, Rice, & Berge, 2012).

Potential benefits

Different higher education institutions share similar concerns, questions, and reasons to apply analytics into operations. Scholars (Dringus, 2012; EDUCAUSE Learning Initiative, 2011; Fournier, Kop, & Sitlia, 2011; Johnson et al., 2013; Jones, 2012; Long & Siemens, 2011; Mandinach & Gummer, 2013; Mattingly et al., 2012; New, 2013; Oblinger, 2013; van Barneveld, Arnold, & Campbell, 2012; van Harmelen & Workman, 2012) have identified the benefits of conducting analytics in higher education at the institutional and operational level, the educational intervention level, and the self-regulated learner level.

The Emerging Field of Learning Analytics

Definition and scope

Knowledge Media Institute at the Open University, United Kingdom, conducted a review of Learning Analytics and concluded that it began to split from Academic Analytics and soon won its own realms and definitions that focus on teaching and learning (Ferguson, 2012). The forming of a professional association: Society of Learning Analytics Research (SOLAR) in 2011 indicated the establishment of the research field in its own right. In the first conference of Learning Analytics and Knowledge (LAK), SOLAR defined Learning Analytics as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Jones, 2012).

Research theme

In SOLAR's LAK11, LAK 12, LAK13 and LAK 14 conferences, the ongoing and future themes in Learning Analytics were widely discussed as follows:

- **Institutional Culture and Policy**: Institutional buy-in, infrastructure, data governance, Mass Open Online Courses, scaling, policy framework, student retention, and capacity building.
- **Theoretical Underpinning**: Educational data mining, visions of analytics, and philosophical and ethical reflection.
- **Teaching and Learning**: Learning community, reflective learning, self-regulated learning, formative assessment, classroom attention, and adaptive intervention.
- **Research Methodology**: Predictive modeling, social learning analytics, variable construction, causal modeling, reflective learning, textual analytics, risk analytics, discourse analytics, affect analytics, and learning-object analytics.

- **Reporting and Visualization**: Adaptive/recommender systems, visual analytics, and e-mentoring.

Data framework

To achieve a holistic understanding of college students, data from demographic information, usage records, and survey results are equally important. Multiple types of data can serve to triangulate and generalize reliable results. Research (Ellis, 2013; Hung et al., 2012; Lodge, 2011; Olmos & Corrin, 2011; Shamah & Ohlsen, 2013) concludes these data should be included for data mining and Learning Analytics purposes:

1. Student information system data: Demographic variables
2. LMS usage data: Learner engagement variables
3. Self-reported survey data: Perception variables
4. Academic record data: Performance variables
5. Institutional data: Contextual and supportive variables

Methodology

In addition to the numerical analyses, content analysis, social network analysis, and natural language processing emphasize the social aspects of learning and are advanced research methods in Learning Analytics. Furthermore, advanced research methods from Computer Mediated Communication (CMC) are widely applied in Learning Analytics to probe students' behaviors more deeply in online social learning processes. To gain a richer picture of learning, Shum and Ferguson (2012) suggested the combinations of socialized analytical methods to discover educational dialogue that highlights to the key to students' success.

Prominent example, market service provider, and scholarly organization

A few universities are pioneering the study and application of Learning Analytics. Course Signal at Purdue University, Student Success Plan at Sinclair Community College, iPortfolio at Curtin University (Australia), Predictive Analytics at Rio Salado College, "Check My Activity" at University of Maryland - Baltimore County, and E^2Coach at University of Michigan are some of the prominent examples. Moreover, market service providers such as Blackboard Analytics for Learn, IBM SPSS Decision Management for Student Retention, Desire2Learn Insights, and Student Success Collaborate of Education Advisory Board provide analytical services for higher education institutions. Currently, SOLAR is the largest international community of analytics scholars in education, which has grounded the definition, scope, and research agenda for Learning Analytics for the past four years. PAR (Predictive Analytics Reporting) is a cross-institutional big-data analysis project that studies the student variables and learns how to improve student retention and academic success via federated

and de-identified data. Research resources and experiences are shared among participating institutions in terms of analytic techniques, research methods, and report visualizations.

Suggestion and Educational Implication

The objectives of Learning Analytics for a higher education institution can be multifold. However, a university needs to consider the applicability and resources availability for Learning Analytics and determine a workable agenda, which combines analytics tools and proper research designs (Phillips et al., 2011). An iterative cycle suggested by van Harmelen and Workman (2012, p. 22) is introduced in the end of this article as a prototype for potential institutions.

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