Trends and Issues in Technology Education Research in Taiwan: A Co-Word Analysis of 1994-2013 Graduate Theses

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Abstract

In Taiwan, the Technology Education for 1-12 graders is comprised of two courses--Living Technology (LT) and Information Technology (IT). With its ever-changing feature, Technology Education needs on-going research to support its decisions and actions. The education-related academic programs in universities regularly concern about the development of primary and secondary education. To identify the evolution directions and knowledge orientation of the research topics of theses and dissertations, from LT and IT education graduate programs, will be helpful for clarifying trends and issues in Technology Education of primary and secondary education. Hence, this study used co-word analysis of bibliometrics to analyze the theses and dissertations from all LT and IT education graduate programs in Taiwan and completed in the last decade (2004~2013 academic years). Totally, 884 LT and 992 IT summaries of theses and dissertations in the database--National Digital Library of Theses and Dissertations in Taiwan, served as the subject of this study. The results show: (1) The number of LT's and IT's theses and dissertations significantly declined; (2) LT's research topical focuses have moved to e-learning, while IT's focuses have changed from universal e-learning to game-based e-learning; (3) The connection between research sub-areas and theme in either LT or IT is not well-structured; and (4) The research topics completed are in lack of teacher education and technological/information literacy.

Keywords: technology education, graduate research, co-word analysis, bibliometrics

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Introduction

Funded by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA), The Technology for All Americans (TfAA) project defines "technology" as "…human innovation in action…". Technology Education, the study of technology, aims to prepare technological literacy for all.

In the upcoming national curriculum for 1-12 graders in Taiwan, both "Living Technology (LT)" and "Information Technology (IT)" are included in the learning area of "Technology Education". Like other fields, Technology Education needs on-going research to support its decisions and actions. The education-related academic programs in universities continuously concern about the development of primary and secondary education through their theses and dissertations. To identify the evolution directions and knowledge orientation of the research topics of theses and dissertations from the LT and IT education graduate programs will be helpful in clarifying trends and issues in Technology Education of primary and secondary education.

This study aimed to identify the evolution directions and knowledge orientation of the research topics of theses and dissertations from LT and IT education graduate programs. Employing automated content mining tool BICOMB (bibliographic item co-occurrence matrix builder, a bibliographic co-occurrence analysis system), co-word matrix, clustering analysis, strategic diagram and social network analysis were established.

Method

If a word (or noun phrase) is used in two or more texts, the word becomes a co-occurrence word (i.e., co-word) between the two or more texts. The more co-words, the texts using the co- words are more similar in topics. Based upon the relationships, co-word analysis is a content analysis technique that uses patterns of co-words in a corpus of texts to identify the relationships between ideas within the subject areas presented in these texts (He, 1999).

This study used co-word analysis of bibliometrics to analyze the evolution directions and knowledge orientation of the research topics of the theses and dissertations from all LT and IT education graduate programs in Taiwan and completed in the last decade (2004~2013 academic years). Totally, 884 LT and 992 IT summaries of dissertations and theses in the database--National Digital Library of Theses and Dissertations in Taiwan, served as the subject of this study.

The data processing procedures of this study are mainly as follows: (1) Filing and coding the keywords on the samples, (2) Checking and modifying some inconsistencies among keywords, (3) Determining the threshold to identifying high-frequency keywords, (4) Dividing the last decade into two phases and building keywords frequency and co-word matrix, (5) Converting the data in the matrix into Spearman's correlation coefficient matrix, and (6) Drawing co-word network maps to explore the internal connection between clusters and nodes as well as structures.

Results

Based on the co-word matrix, clustering analysis, strategic coordinate and social network analysis completed for LT and IT, respectively, the results are as follows:

The Evolution Directions and Knowledge Orientation of LT

1. There is a downward trend in the number of theses
   There were 471 theses completed in Phase I (2004~2008 academic year), which include 421 master's theses and 50 doctoral dissertations. There were 413 theses completed in Phase II (2009~2013 academic year), which include 349 master's theses and 64 doctoral dissertations.

2. Multi-disciplinary research topics are presented and diverse academic communities exist
   According to Price (1965), the range, 45-50, was selected to become the threshold to determine the high frequency keywords. As shown in Table 1, the cumulative percentage of high frequency keywords in Phases I and II are 4.97%, 8.57%, respectively. It indicates that the high frequency keywords are made by a handful of cumulative keywords; however, multi-disciplinary research topics are presented and diverse academic communities exist.

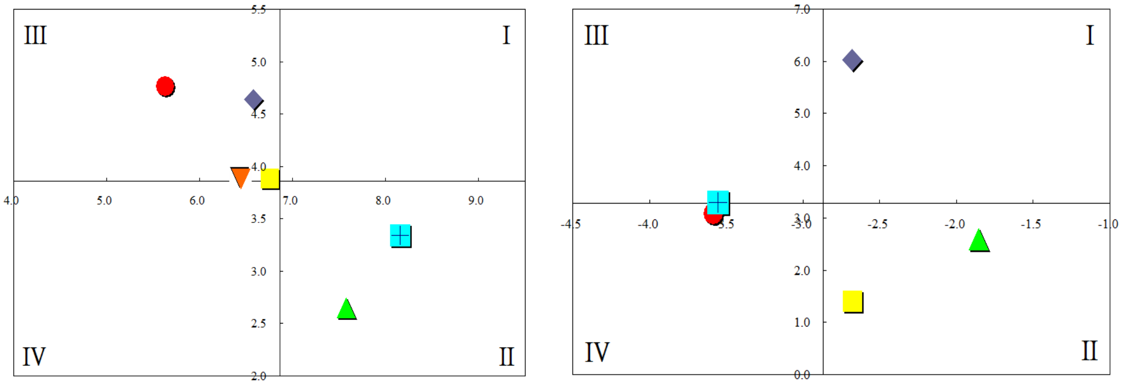
Table 1: The frequency of LT keywords

Frequency	Phase I (2004~2008)			Phase II (2009~2013)		
	Number	Cumulative Frequency	Cumulative %	Number	Cumulative Frequency	Cumulative %
25~29	0	0	0.00	0	0	0.00
20~24	0	0	0.00	1	1	0.09
15~19	2	2	0.17	0	1	0.18
10~14	6	8	0.86	6	7	0.82
5~9	40	48	4.97	29	36	4.10
4	16	64	10.55	13	49	8.57
3	46	110	19.88	42	91	16.86
2	108	218	38.56	111	202	35.28
1	949	1,167	100.00	895	1,097	100.00

3. Research topical focuses have moved to e-learning
   The 48 representative keywords in Phase I can be categorized into the following six clusters: competency development, technology-oriented instruction for human resources, curriculum development, workplace satisfaction, instructional strategies in technology education, and learning factors. The 49 representative keywords in Phase II can be categorized into the following five clusters: instructional models in technology education, career exploration, organizational learning, e-learning and workplace satisfaction. The cluster, e-learning, appears in Phase II. The number of research topics concerning the technology education in primary and secondary education is shrinking, while the number of research topics regarding technology-oriented human resources for the industry is relatively expanded.

   In addition, the degree centrality and density of each cluster are shown in Figure 1. The centrality represents the connection strength among the cluster and other clusters. The cluster having high centrality tends to be the core cluster in the network of clusters. The density stands for the strength of internal closeness. The cluster having high density tends to have more coherent, more complete and more durable corresponding research topics.

4. The connection between research sub-areas and theme is not well-structured
   As shown in Figure 2 (left), the empty core and the distance between the clusters indicates that the connection among research topics is weak and core research topics have not appeared yet. As shown in Figure 2 (right), technology-oriented human resources become the research focus and researches regarding Technology Education in primary and secondary education are relatively scattered, weak and marginalized.

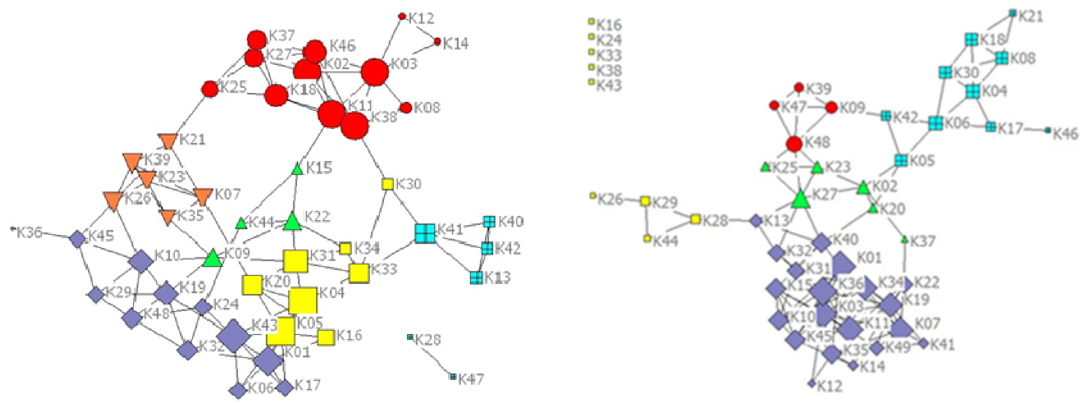


● competency development (5.63, 4.76)
□ technology-oriented instruction for human resources (6.76, 3.88)
△ curriculum development (7.58, 2.65)
⊞ workplace satisfaction (8.15, 3.34)
◆ instructional strategies in technology education (6.58, 4.64)
▽ learning factors (6.50, 3.89)

● instructional models in technology education (-3.58, 3.08)
□ career exploration (-2.67, 1.40)
△ organizational learning (-1.85, 2.59)
⊞ e-learning (-3.55, 3.30)
◆ workplace satisfaction (-2.68, 6.02)

Notes: Quadrant I--high centrality, high density; Quadrant II--high centrality, low density; Quadrant III--low centrality, high density; Quadrant IV--low centrality, low density; (centrality, density)

Figure 1: The strategic coordinates of LT clusters in Phases I (left) and II (right)



● competency development
□ technology-oriented instruction for human resources
▲ curriculum development
⊞ workplace satisfaction
◆ instructional strategies in technology Education
▼ learning factors

● instructional models in technology education
□ career exploration
▲ organizational learning
⊞ e-learning
◆ workplace satisfaction

Note: The keywords/nodes in the above two maps are listed in Appendix 1.

Figure 2: The network maps of LT clusters in Phases I (left) and II (right)

<u>The Evolution Directions and Knowledge Orientation of IT</u>

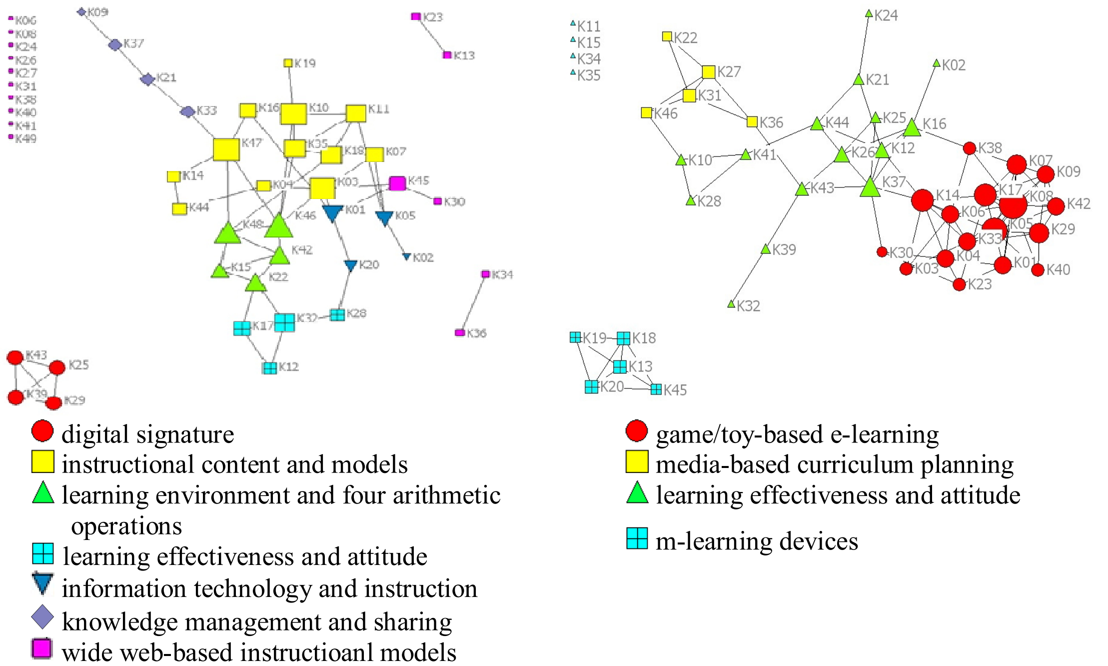
1. There is a downward trend in the number of theses
   There were 542 theses completed in Phase I (2004~2008 academic year), which include 531 master's theses and 11 doctoral dissertations. There were 450 theses completed in Phase II (2009~2013 academic year), which include 444 master's theses and 6 doctoral dissertations.

2. Research topics are broadened but it is doubtful whether in-depth studies are enough
   As shown in Table 2, the cumulative percentage of high-frequency keywords in Phases I and II are 4.02%, 4.41%, respectively.

Table 2: The frequency of IT keywords

Frequency	Phase I (2004~2008)			Phase II (2009~2013)		
	Number	Cumulative Frequency	Cumulative %	Number	Cumulative Frequency	Cumulative %
25~29	0	0	0.00	0	0	0.00
20~16	1	1	0.08	2	1	0.10
10~15	12	13	1.07	14	15	1.44
6~9	24	37	3.03	31	46	4.41
5	11	49	4.02	13	59	5.66
4	30	78	6.39	19	78	7.48
2~3	156	234	19.18	143	221	21.19
1	986	1220	100.00	822	1043	100.00
1	949	1,167	100.00	895	1,097	100.00

3. Research focuses have moved toward game/toy-based e-learning
   The clusters in Figure 3 (left) are scattered, while the nodes in the cluster of game/toy-based e-learning have high closeness. It indicates that from Phase I to Phase II research focuses have moved toward game/toy-based e-learning.



Note: The keywords in the above two maps are listed in Appendix 2.

Figure 3: The network maps of IT clusters in Phases I (left) and II (right)

<u>A Concern about the Nature of the Departments Producing the Theses Analyzed</u>

Basically, the departments producing the theses analyzed in this study also prepare LT or IT teachers for primary and secondary schools, who are expected to promote technological/information literacy education. However, few research topics regarding teacher education and technological/information literacy are found in this study (Fang & Lee, 2014).

Conclusion

In conclusion, the results of this study are as follows: (1) The number of LT's and IT's theses and dissertations significantly declined; (2) LT's research topical focuses have moved to e-learning, while IT's research focuses have changed from universal e-learning to game-based e-learning; (3) The connection between research sub-areas and theme in either LT or IT is not well-structured; and (4) The research topics completed are in lack of teacher education and technological/information literacy.

On September 18, 2013, Cindy Sui in her commentary report on BBC, entitled "Taiwan's struggle to become an innovation leader", raised the question "Taiwan became a manufacturing powerhouse and the centre of the world's laptop production. But it's a difficult place to launch successful start-ups. Can it rise to the challenge?"

When the authors read the report, the slogan in the advertisement of DuPont, “Together, we can solve the world’s greatest challenges.”, was posted beside the report. Certainly, working together can make a difference and Technology Education research should be a part of it to promote technological development and technology education in Taiwan.

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Appendix 1.

The keywords/nodes in Figure 2--Phases I (left) and II (right)

Phase I (left)

Cluster	Number	Keywords
● (1)	K02	competency
	K03	delphi method
	K08	e-learning
	K11	key success factors
	K12	concepts
	K14	indicators
	K18	temporary employment
	K25	knowledge management
	K27	education and training
	K37	non-profitable organization
	K38	organization change
	K46	competency model
■ (2)	K04	creativity
	K05	technological creativity
	K16	problem-solving
	K20	structural equation modeling
	K30	human resource
	K31	technology acceptance model
	K33	personality
	K34	information technology
▲ (3)	K09	learning effects
	K15	career development
	K22	learning satisfaction
	K44	learning motivation
⊞ (4)	K13	organizational commitment
	K28	vocational values
	K40	turnover intention
	K41	job satisfaction
	K42	job stress
	K47	value
◆ (5)	K01	living technology
	K06	technology education
	K10	science and technology
	K17	information integration
	K19	web-base instruction
	K24	cooperative learning
	K29	satisfaction
	K32	technology concept
	K36	knowledge management

Phase II (right)

Cluster	Number	Keywords
● (1)	K09	action research
	K39	cooperative learning
	K47	project-based learning
	K48	information technology
■ (2)	K16	unified theory of acceptance and use of technology
	K24	competency
	K26	living technology
	K28	career development
	K29	junior high school student
	K33	attitude
	K38	energy saving and carbon reduction
	K43	technological creativity
	K44	analytical hierarchy process
▲ (3)	K02	knowledge sharing
	K20	innovative behavior
	K23	organizational innovation
	K25	knowledge management
	K27	organizational learning
	K37	mentoring functions
⊞ (4)	K04	e-learning
	K05	learning motivation
	K06	learning effectiveness
	K08	satisfaction
	K17	learning attitude
	K18	technology acceptance model
	K21	augmented reality
	K30	learning style
	K42	interactive whiteboards
	K46	internet addiction
◆ (5)	K01	organizational commitment
	K03	job involvement
	K07	turnover intention
	K10	organizational citizenship behavior
	K11	job benefit
	K12	self-efficacy
	K13	job satisfaction
	K14	job performance
	K15	job passion
	K19	organizational

		capability
	K43	concept maps
	K45	competence indicators
	K48	action research
▼ (6)	K07	mobile learning
	K21	knowledge transfer
	K23	web-based learning
	K26	influence factors
	K35	problem-based learning
	K39	learning style

		identification
	K22	perceived organizational support
	K31	employee engagement
	K32	organizational climate
	K34	work values
	K35	job stress
	K36	job characteristic
	K40	workplace friendship
	K41	internal marketing
	K45	emotional labor
	K49	job contentment

Appendix 2.
The keywords/nodes in Figure 3--Phases I (left) and II (right)

Cluster	Number	Keywords
●(1)	K39	elliptic curve digital signature algorithm
	K43	public key
	K25	PKI
	K29	certificate management
□(2)	K16	ontology
	K47	Delphi technique
	K10	SCORM
	K19	concept mapping
	K14	e-learning effectiveness
	K44	adaptive learning materials
	K03	project-based learning
	K04	cooperative learning
	K07	programming
	K18	learning styles
	K35	problem solving
	K11	learning effect
△(3)	K46	learning satisfaction
	K48	learning motivation
	K22	case study
	K42	situational learning
	K15	addition, subtraction, multiplication, division, fraction
⊞(4)	K28	multimedia
	K32	mathematics learning attitudes
	K12	mathematics history
	K17	mathematics learning attitudes
▽(5)	K02	integrating information technology into instruction
	K05	mobile learning
	K20	technology acceptance model
	K01	e-learning
◇(6)	K09	data mining
	K37	blog
	K21	knowledge sharing
	K33	knowledge management
■(7)	K30	data stream
	K45	learning portfolio
	K13	action research
	K23	information incorporating teaching

Cluster	Number	Keywords
●(1)	K03	game-based learning
	K09	action research
	K06	experiential learning
	K42	case study
	K17	inquiry-based learning
	K33	ubiquitous learning
	K08	learning attitude
	K14	scaffolding theory
	K29	geometry
	K05	learning effect
	K01	programming
	K40	learning styles
	K07	problem solving
	K38	blog
	K23	scratch programming
	K30	information technology education
	K04	augmented reality
□(2)	K27	prior knowledge
	K31	cooperative learning
	K46	misconception
	K22	cognitive load
	K36	multimedia materials
△(3)	K25	mathematics learning attitudes
	K28	concept mapping
	K26	mistake types
	K41	content analysis
	K16	gender
	K10	remedial teaching
	K37	problem-solving strategy
	K39	symmetry
	K02	spatial ability
	K43	mathematical attitudes
	K21	elementary school students
	K32	reading comprehension
	K24	addition, subtraction, multiplication, division
	K34	online reading
	K12	math learning attitude

	K34	data classification
	K36	genetic algorithm
	K41	web-base instruction
	K49	formative assessment
	K06	self-efficacy
	K40	instant message
	K38	scaffolding theory
	K08	questioning-assisted instruction
	K31	ZMET
	K27	English e-learning
	K26	workflow
	K24	mobile devices
	K35	professional development of teachers
	K44	mathematical problem solving
	K11	digital game
	K15	fractional materials
(4)	K18	android
	K20	mobile forensics
	K13	digital evidence
	K19	smartphone
	K45	social network