

*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

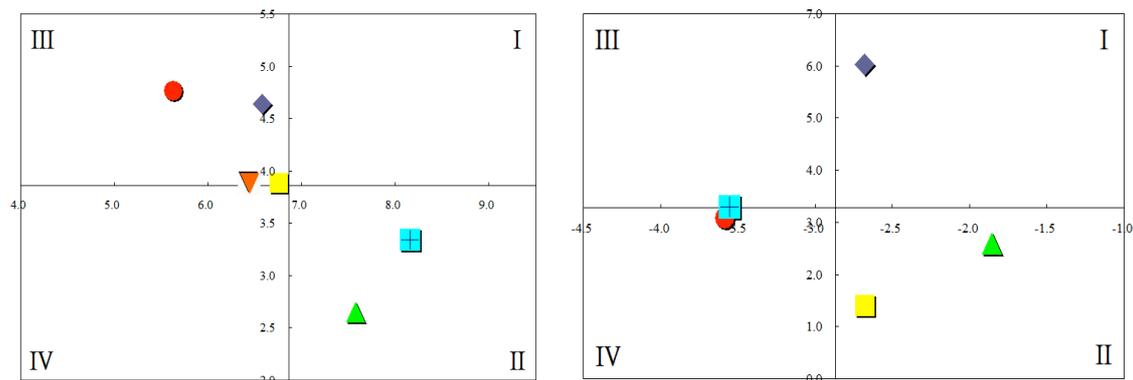
3. Research topical focuses have moved to e-learning

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.

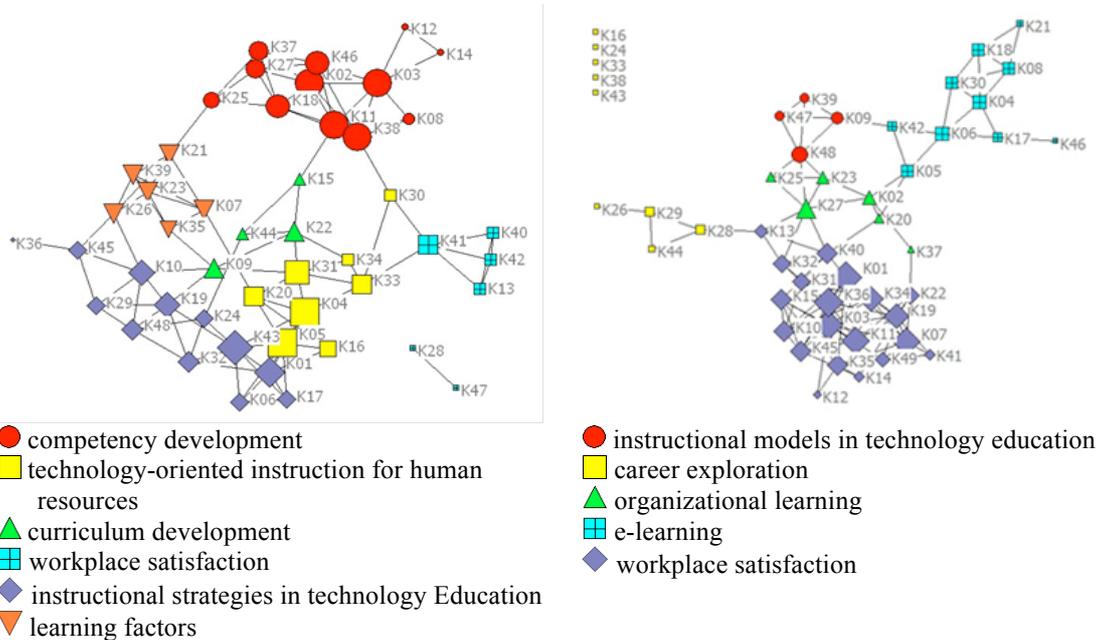
4. The connection between research sub-areas and theme is not well-structured
 As shown in Figure 2 (left), the empty core and the distance between the clusters indicates that the connection among research topics is weak and core research topics have not appeared yet. As shown in Figure 2 (right), technology-oriented 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)



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)

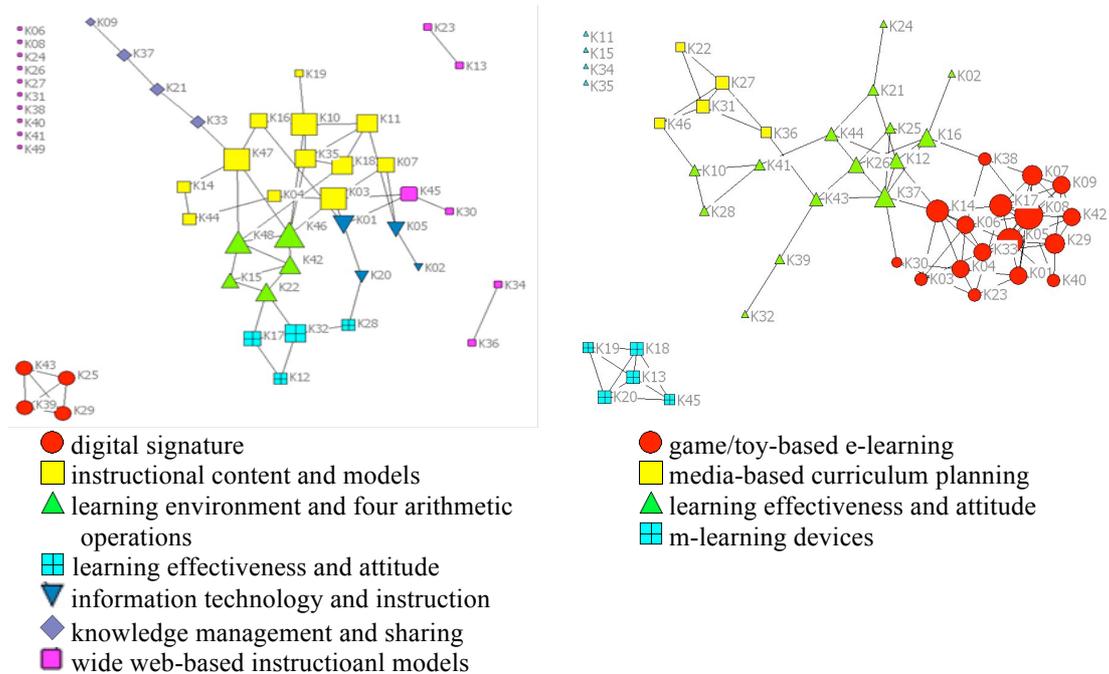
The Evolution Directions and Knowledge Orientation of IT

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	1	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)

A Concern about the Nature of the Departments Producing the Theses Analyzed

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.

The results of this study can be used by the technology educators in Taiwan to identify what they should focus on to promote technology education research studies. In addition, the method used in this study can be employed in all academic fields to identify their trends and issues.

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Appendix 1.

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

Cluster	Number	Keywords	Cluster	Number	Keywords
●(1)	K02	competency	●(1)	K09	action research
	K03	delphi method		K39	cooperative learning
	K08	e-learning		K47	project-based learning
	K11	key success factors		K48	information technology
	K12	concepts	K16	unified theory of acceptance and use of technology	
	K14	indicators	K24	competency	
	K18	temporary employment	K26	living technology	
	K25	knowledge management	K28	career development	
	K27	education and training	■(2)	K29	junior high school student
	K37	non-profitable organization	K33	attitude	
K38	organization change	K38	energy saving and carbon reduction		
K46	competency model	K43	technological creativity		
K04	creativity	K44	analytical hierarchy process		
■(2)	K05	technological creativity	▲(3)	K02	knowledge sharing
	K16	problem-solving		K20	innovative behavior
	K20	structural equation modeling		K23	organizational innovation
	K30	human resource		K25	knowledge management
	K31	technology acceptance model		K27	organizational learning
	K33	personality		K37	mentoring functions
	K34	information technology		K04	e-learning
▲(3)	K09	learning effects	K05	learning motivation	
	K15	career development	K06	learning effectiveness	
	K22	learning satisfaction	K08	satisfaction	
	K44	learning motivation	K17	learning attitude	
■(4)	K13	organizational commitment	■(4)	K18	technology acceptance model
	K28	vocational values		K21	augmented reality
	K40	turnover intention		K30	learning style
	K41	job satisfaction		K42	interactive whiteboards
	K42	job stress		K46	internet addiction
	K47	value		K01	organizational commitment
◆(5)	K01	living technology	◆(5)	K03	job involvement
	K06	technology education		K07	turnover intention
	K10	science and technology		K10	organizational citizenship behavior
	K17	information integration		K11	job benefit
	K19	web-base instruction		K12	self-efficacy
	K24	cooperative learning		K13	job satisfaction
	K29	satisfaction		K14	job performance
	K32	technology concept		K15	job passion
	K36	knowledge management		K19	organizational

		capability			identification
	K43	concept maps		K22	perceived organizational support
	K45	competence indicators		K31	employee engagement
	K48	action research		K32	organizational climate
	K07	mobile learning		K34	work values
	K21	knowledge transfer		K35	job stress
▼ (6)	K23	web-based learning		K36	job characteristic
	K26	influence factors		K40	workplace friendship
	K35	problem-based learning		K41	internal marketing
	K39	learning style		K45	emotional labor
				K49	job contentment

Appendix 2.

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

Cluster	Number	Keywords	Cluster	Number	Keywords
●(1)	K39	elliptic curve digital signature algorithm	●(1)	K03	game-based learning
	K43	public key		K09	action research
	K25	PKI		K06	experiential learning
	K29	certificate management		K42	case study
■(2)	K16	ontology		K17	inquiry-based learning
	K47	Delphi technique		K33	ubiquitous learning
	K10	SCORM		K08	learning attitude
	K19	concept mapping		K14	scaffolding theory
	K14	e-learning effectiveness		K29	geometry
	K44	adaptive learning materials		K05	learning effect
	K03	project-based learning		K01	programming
	K04	cooperative learning		K40	learning styles
	K07	programming		K07	problem solving
	K18	learning styles		K38	blog
K35	problem solving	K23	scratch programming		
K11	learning effect	K30	information technology education		
▲(3)	K46	learning satisfaction	K04	augmented reality	
	K48	learning motivation	K27	prior knowledge	
	K22	case study	K31	cooperative learning	
	K42	situational learning	K46	misconception	
■(4)	K15	addition, subtraction, multiplication, division, fraction	■(2)	K22	cognitive load
	K28	multimedia		K36	multimedia materials
	K32	mathematics learning attitudes	K25	mathematics learning attitudes	
	K12	mathematics history	K28	concept mapping	
▼(5)	K17	mathematics learning attitudes	K26	mistake types	
	K02	integrating information technology into instruction	K41	content analysis	
	K05	mobile learning	K16	gender	
	K20	technology acceptance model	K10	remedial teaching	
◆(6)	K01	e-learning	▲(3)	K37	problem-solving strategy
	K09	data mining		K39	symmetry
	K37	blog		K02	spatial ability
	K21	knowledge sharing	K43	mathematical attitudes	
■(7)	K33	knowledge management	K21	elementary school students	
	K30	data stream	K32	reading comprehension	
	K45	learning portfolio	K24	addition, subtraction, multiplication, division	
	K13	action research	K34	online reading	
K23	information incorporating teaching	K12	math learning attitude		

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

□(4)