# Research characteristics and patterns in engineering education: content analysis 2000-2009

**Pao-Nan Chou† & Chi-Cheng Chang‡**

National University of Tainan, Tainan, Taiwan†
National Taiwan Normal University, Taipei, Taiwan‡

ABSTRACT: In the field of engineering education, the *Journal of Engineering Education* (JEE) is one of the publications listed in the ISI Thomson citation index. Analysing JEE articles may offer a clear understanding of characteristics and patterns in engineering education research. The aim of this study was to investigate the research characteristics present in the JEE from 2000 to 2009, and provide research patterns for engineering educators or those with an interest in engineering education research. A modified, four-step content analysis, which contains sampling, conceptualisation, operationalisation, and coding verification, analyse published works in JEE since 2000. Based on the analysed results from seven focus areas: a) characteristics of research methods; b) research subject; c) engineering discipline; d) research topic; e) citation information; f) author's geographical affiliation; and g) article keywords, 10 major findings were yielded from this study. Several suggestions are proposed for engineering education researchers.

## INTRODUCTION

The *Journal of Engineering Education* (JEE) has the reputation of being a reliable source, which disseminates professional knowledge of research for engineering educators [1]. The JEE is also listed in the Social Science Citation Index (SSCI), which collects prominent journals through a rigorous review mechanism [2].

From 2007 to 2009, based on the score of impact factor, the JEE was one of the top five SSCI journals [2]. For this reason, examining scholarly works in the JEE may offer a thorough understanding of research characteristics and patterns in the field of engineering education.

Content analysis is a research method that can systematically provide an objective insight into message content through quantitative representation [3]. In the existing literature, content analysis has enjoyed wide use to identify research characteristics and patterns in certain research domains for specific periods of time [4-6].

Despite lacking elaboration of the use of content analysis in research design, two related studies attempted to analyse JEE articles. Whitin and Sheppard [7] and Wankat [1] reviewed scholarly works in the JEE from 1996 to 2001 and from 1993 to 2002, respectively. These scholars identified several research patterns from different methodological perspectives; however, to promote academic exchange in engineering education research, new analytical methods and strategies for examining JEE publications are necessary.

The current study aims to apply content analysis to analyse published works in the JEE since 2000. This timeframe is common for a decade-review in journalism (e.g. Gordon [8]).

The purpose of this study was to investigate research characteristics in the JEE from 2000 to 2009, and provide research patterns for engineering educators or those interested in engineering education research. Specifically, the research questions of this decade-review study are:

1. What are the characteristics of research methods for papers published in the JEE in the past ten years?
2. To what educational levels do research subjects apply as represented by JEE articles in the past ten years?
3. What percentage of engineering disciplines have been discussed in the JEE in the past ten years?
4. What kinds of research topics have been published in the JEE in the past ten years?
5. What are the JEE research articles frequently cited in SSCI in the past ten years?
6. What diverse nationalities represent contributors to the JEE in the past ten years?
7. What were the important concepts, listed as keywords, in the JEE in the past ten years?

## RESEARCH METHODS

### Research Design

This study modified the Neuendorf [3] and Gall, Gall, and Borg [9] models for content analysis. The four major research procedures are:

1. *Sampling (content selection)*: This study only selected research-based papers published in the JEE from 2001 to 2009 for further analysis. Articles, such as book reviews, workshops (or conference) summaries, editorials (or guest editorials), and prize lectures, were excluded. A total of 437 research articles from the ten-year period form the dataset.
2. *Conceptualisation (question specification)*: Seven research questions discussed earlier are proposed. This study focused on seven research areas: a) characteristics of research methods; b) research subject; c) engineering discipline; d) research topic; e) citation information; f) author's geographical affiliation; and g) article keywords.
3. *Operationalisation (variable identification)*: Based on research questions, a coding book, which summarises coding strategies, was created. In this study, except for research discipline, citation information and article keywords, the variable range in characteristics of research methods is one to four; in research subject, one to five; in research topic, one to six; and in author's geographical affiliation, one to seven.
4. *Coding verification (reliability check)*: Instead of inter-reliability analysis, this study adopted a triangulation method to verify coding strategies. During the coding process, one novice professor and one doctoral student collaboratively processed selected journal articles. Subsequently, an experienced professor in engineering education corroborated evidence from submitted coding data.

### Characteristics of Research Methods for Analysis

Research methods' characteristics consist of four elements: research approach, quantitative-based inquiry, statistical analysis and qualitative-based inquiry. Table 1 summarises the coding variables in these elements.

Table 1: Research methods' coding strategies.

| Item | Variables |
|---|---|
| Research approach | 1. Theoretical inquiry: A study aims to propose new ideas without assessment data.<br>2. Quantitative-based: A study aims to investigate specific topics by providing qualitative assessment data.<br>3. Qualitative-based: A study aims to investigate specific topics by providing quantitative assessment data.<br>4. Mixed-methods: A study aims to investigate specific topics by providing quantitative and qualitative assessment data. |
| Quantitative-based inquiry | 1. None: No quantitative methods were used in a study.<br>2. Survey: A study primarily using a survey method.<br>3. Experiment: A study primarily using an experimental method.<br>4. Others: A study uses other quantitative methods, such as data mining, rather than any of the previously mentioned methods. |
| Statistical analysis | 1. None: No statistics are used in a study.<br>2. Descriptive statistics: A study only provides descriptive statistics.<br>3. Inferential statistics: A study only provides inferential statistics.<br>4. Mixed: A study provides both descriptive and inferential statistics. |
| Qualitative-based inquiry | 1. None: No qualitative methods are used in a study.<br>2. Interview: A study primarily uses an interview method.<br>3. Open-ended survey: A study primarily uses an open-ended survey method.<br>4. Others: A study uses other qualitative methods, such as observations or document analyses, rather than any of the previously mentioned methods. |

### Research Subject for Analysis

Research subjects analysed in this study are engineering students or faculty which participated in the studies. Determination of research subjects' appropriate educational levels used divisions of: a) none: no participant; b) K-12 students; c) college students; d) graduate students; and e) others: faculty or alumni (engineers).

### Engineering Discipline for Analysis

Article contributors to the JEE conducted educational studies in several engineering disciplines. For example, authors explored instructional strategies for specific engineering students or engineering curricula (e.g. civil engineering students or chemical engineering curricula). However, articles that did not focus on specific engineering disciplines were not considered for further analysis.

Research Topic for Analysis

Two guidelines categorise research topics in this study: First, according to a special report published in the JEE [10], five research areas: a) engineering epistemologies; b) engineering learning mechanisms; c) engineering learning systems; d) engineering diversity and inclusiveness; and e) engineering assessment, constitute research themes. Second, within each research theme, several research topics arise from engineering education conferences' topic categorisation. For instance, conferences held by the American Society of Engineering Education (ASEE) and European Society of Engineering Education (ESEE) are main reference sources. Details of categorisation of research topics appear in Table 2.

Table 2: Coding strategies in research topics.

| Research Theme | Research Topic |
|---|---|
| Engineering epistemologies | 1. Professional competency needs for engineering students<br>2. Engineering students' (or engineers) attitudes toward diverse issues (non-learning related)<br>3. Factors influencing students' success (retention and dropout) in engineering programs |
| Engineering learning mechanisms | 1. Instructional design (instructional strategies, activities, and techniques) to improve students' learning outcomes<br>2. Learning in distance education (on-line courses)<br>3. Design, development, and evaluation of instructional media (educational games, simulations, simulators, and software) to support student learning<br>4. Learning in engineering ethics<br>5. Learning in engineering writing<br>6. Students working with projects |
| Engineering learning systems | 1. Curriculum design, development, implementation and evaluation<br>2. Academic program design, development, implementation and evaluation<br>3. Issues in overall development of engineering education<br>4. Faculty professional development<br>5. Content analysis of Journal of Engineering Education |
| Engineering diversity and inclusiveness | 1. Engineering minority groups (ethnic issues)<br>2. Gender issues (females in the engineering world)<br>3. Status of engineering education in other countries<br>4. Development of K-12 engineering education |
| Engineering assessment | 1. Faculty teaching assessment<br>2. Assessment methods and assessment development<br>3. Institution assessment |

SSCI for Analysis

Examining frequently cited research articles in the JEE can provide an in-depth view of the professional knowledge areas receiving the most attention. This study used the SSCI database to obtain citation information. The time end-point for data retrieval was the December 2009. The top ten most frequently cited research papers were analysed for aspects of research method, research subject, engineering discipline and research theme. Since the current SSCI database did not process JEE records from 2000 to 2003, the current study only reports analytical results from 2004 to 2009.

Author's Geographical Affiliation for Analysis

An assumption in the current study is that diverse nationalities of articles' contributors in the JEE represent JEE's internationalisation. Authors' geographical affiliations represent seven classification areas: a) North America (e.g. US); b) South America (e.g. Mexico); c) Europe (e.g. Germany); d) Middle East (e.g. Turkey); f) Asia-Pacific (e.g. Korea); g) South Asia (e.g. Australia); and g) Africa (e.g. South Africa). This study only analyses each article's first author's affiliation.

Keywords for Analysis

Keywords listed in journal articles represent major theoretical concepts [11]. Since JEE articles from 2000 to 2003 did not contain keywords, this study only collects keywords data listed in journal articles from 2004 to 2009. After data collection, a frequency distribution analyses the keywords.

RESULTS AND DISCUSSION

Characteristics of Research Methods for Analysis

Tables 3 to 6 report summaries of research approach, quantitative-based inquiry, statistical analysis and qualitative-based inquiry, respectively.

Table 3: Summary of research approach.

| Year | Theoretical Inquiry | Quantitative-based | Qualitative-based | Mixed-method |
|---|---|---|---|---|
| 2000 | 33 | 21 | 3 | 4 |
| 2001 | 46 | 38 | 5 | 3 |
| 2002 | 18 | 36 | 2 | 3 |
| 2003 | 11 | 25 | 1 | 2 |
| 2004 | 7 | 26 | 0 | 0 |
| 2005 | 13 | 19 | 2 | 1 |
| 2006 | 6 | 16 | 2 | 3 |
| 2007 | 2 | 13 | 8 | 5 |
| 2008 | 9 | 17 | 3 | 5 |
| 2009 | 5 | 19 | 2 | 3 |
| Total | 150 | 230 | 28 | 29 |

Table 4: Summary of quantitative-based inquiry.

| Year | None | Survey | Experiment | Others |
|---|---|---|---|---|
| 2000 | 36 | 14 | 4 | 7 |
| 2001 | 51 | 28 | 5 | 8 |
| 2002 | 20 | 20 | 7 | 12 |
| 2003 | 12 | 6 | 8 | 13 |
| 2004 | 7 | 5 | 8 | 13 |
| 2005 | 15 | 9 | 4 | 7 |
| 2006 | 8 | 6 | 7 | 6 |
| 2007 | 10 | 5 | 1 | 12 |
| 2008 | 12 | 10 | 4 | 8 |
| 2009 | 7 | 11 | 7 | 4 |
| Total | 178 | 114 | 55 | 90 |

Table 5: Summary of statistical analysis.

| Year | None | Descriptive | Inferential | Mixed |
|---|---|---|---|---|
| 2000 | 36 | 16 | 0 | 9 |
| 2001 | 51 | 24 | 3 | 14 |
| 2002 | 20 | 24 | 3 | 12 |
| 2003 | 12 | 14 | 1 | 12 |
| 2004 | 7 | 10 | 0 | 16 |
| 2005 | 15 | 7 | 0 | 13 |
| 2006 | 8 | 6 | 0 | 13 |
| 2007 | 10 | 7 | 0 | 11 |
| 2008 | 12 | 4 | 0 | 18 |
| 2009 | 7 | 4 | 1 | 17 |
| Total | 178 | 116 | 8 | 135 |

Table 6: Summary of qualitative-based inquiry.

| Year | None | Interview | Open-ended survey | Others |
|---|---|---|---|---|
| 2000 | 51 | 2 | 0 | 5 |
| 2001 | 82 | 3 | 4 | 1 |
| 2002 | 54 | 1 | 2 | 2 |
| 2003 | 36 | 2 | 1 | 0 |
| 2004 | 32 | 0 | 0 | 0 |
| 2005 | 31 | 1 | 0 | 2 |
| 2006 | 22 | 4 | 1 | 0 |
| 2007 | 14 | 8 | 1 | 4 |
| 2008 | 25 | 6 | 1 | 1 |
| 2009 | 24 | 5 | 0 | 0 |
| Total | 371 | 32 | 10 | 15 |

From the information presented in Table 3, quantitative-based research dominated the category of research approaches. The quantity of quantitative-based papers is more than one-half of the total papers (230/437=53%). Whether or not engineering educators prefer to employ a quantitative methodology to conduct research is worthy of further exploration.

From an annual-analysis perspective, a limited number of qualitative-based (28/437=6%) and mixed-method based (29/437=7%) studies were identified. Apparently, qualitative-based and mixed-methods research is not popular in the field of engineering education. Regarding the papers classified according to theoretical inquiry, annual publications decreased significantly in ten years. From 2006 to 2009, the annual number of theoretical studies does not exceed 10. A possible explanation may be that the characteristics of JEE articles gravitated toward empirical research.

In the category of quantitative-based inquiry shown in Table 4, the majority of quantitative research (including mixed-methods studies) skewed toward use of surveys (114/259=44%) and other sources (90/259=35%), such as data mining, to design studies.

The experimental method (55/259=21%) is a less frequently employed research approach. By examining the statistical analysis in all quantitative research listed in Table 5, only a few quantitative studies (8/259=3%) reported their findings through inferential statistics. More than half of studies (135/259=52%) contained descriptive and inferential statistics. Using descriptive statistics (116/259=45%) to conduct research is an alternative choice.

In the category of qualitative-based inquiry shown in Table 6, more than half of qualitative studies (including mixed-method studies) employed the interview technique to collect data (32/57=56%). Open-ended surveys (10/57=18%) and other sources (15/57=26%), such as observations or document analyses, are other mainstream techniques.

Research Subject for Analysis

Table 7 shows a summary of research participants representing different educational levels. Results indicated 75% of research participants in JEE articles were college students (204/273=75%) followed by others (51/273=19%). Few studies recruited K-12 (7/273=3%) and graduate (11/273=4%) students, which indicates that low-level (K-12) and high-level (graduate) are not focuses for JEE engineering educators.

Table 7: Summary of research participants at different educational levels.

| Year | None | K-12 | College | Graduate | Others |
|---|---|---|---|---|---|
| 2000 | 34 | 0 | 18 | 6 | 3 |
| 2001 | 46 | 0 | 34 | 2 | 10 |
| 2002 | 21 | 2 | 30 | 1 | 5 |
| 2003 | 13 | 0 | 23 | 0 | 3 |
| 2004 | 10 | 2 | 16 | 1 | 4 |
| 2005 | 14 | 0 | 16 | 0 | 5 |
| 2006 | 6 | 2 | 16 | 0 | 3 |
| 2007 | 3 | 0 | 16 | 1 | 8 |
| 2008 | 12 | 1 | 16 | 0 | 5 |
| 2009 | 5 | 0 | 19 | 0 | 5 |
| Total | 164 | 7 | 204 | 11 | 51 |

Engineering Discipline for Analysis

Table 8 reports a summary of engineering disciplines with high frequency of appearance in the JEE. Top three engineering disciplines discussed in JEE are mechanical engineering (39), electrical and computer engineering (29), and civil engineering (25). Notably, 291 JEE articles did not describe specific engineering disciplines in detail. Most of these studies often used an umbrella term *engineering students* in the description of the research design; some of these studies recruited several students from various engineering disciplines.

Table 8: Summary of engineering discipline.

| Ranking | Engineering Discipline | Frequency (more than 10) |
|---|---|---|
| 1 | Mechanical engineering | 39 |
| 2 | Electrical and computer engineering | 29 |
| 3 | Civil engineering | 25 |
| 4 | Biomedical engineering | 17 |
| 5 | Chemical engineering | 13 |
| 6 | Industrial engineering | 10 |

*Specific engineering disciplines were not reported in 291 studies.

Research Topic for Analysis

A summary of research themes appears in Table 9. A matrix representing the relationship between research theme and research topic appears in Table 10. Data from Table 9, transformed to a graphic representation, appears in Figure 1.

Table 9: Summary of research themes.

| Year | Engineering Epistemologies | Engineering Learning Mechanisms | Engineering Learning Systems | Engineering Diversity and Inclusiveness | Engineering Assessment |
|---|---|---|---|---|---|
| 2000 | 2 | 39 | 16 | 3 | 1 |
| 2001 | 3 | 50 | 32 | 4 | 3 |
| 2002 | 0 | 27 | 22 | 4 | 6 |
| 2003 | 1 | 15 | 13 | 2 | 8 |
| 2004 | 1 | 16 | 12 | 0 | 4 |
| 2005 | 3 | 17 | 8 | 3 | 4 |
| 2006 | 3 | 15 | 8 | 1 | 0 |
| 2007 | 3 | 10 | 6 | 6 | 3 |
| 2008 | 9 | 10 | 6 | 4 | 5 |
| 2009 | 6 | 12 | 6 | 5 | 0 |
| Total | 31 | 211 | 129 | 32 | 34 |

Table 10: Matrix between research theme and research topic.

| Research Topic* | Engineering Epistemologies | Engineering Learning Mechanisms | Engineering Learning Systems | Engineering Diversity and Inclusiveness | Engineering Assessment |
|---|---|---|---|---|---|
| 1 | 13 | 133 | 54 | 7 | 5 |
| 2 | 6 | 16 | 38 | 13 | 25 |
| 3 | 12 | 30 | 21 | 5 | 4 |
| 4 | 0 | 10 | 13 | 7 | 0 |
| 5 | 0 | 6 | 3 | 0 | 0 |
| 6 | 0 | 16 | 0 | 0 | 0 |
| Total | 31 | 211 | 129 | 32 | 34 |

* Details of research topics appear in Table 2.

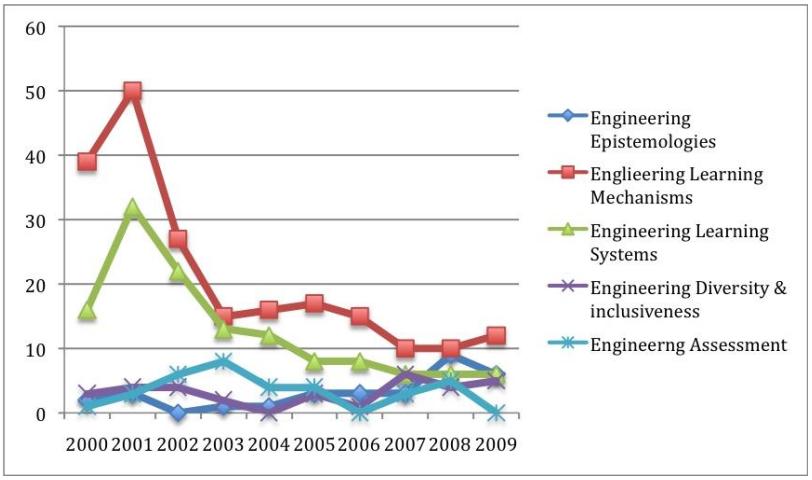


Figure 1: Graphic representative in five research themes.

From the information shown in Table 9, the primary focus of all research papers was on engineering learning mechanisms (211/437=48%) and engineering learning systems (129/437=30%). The other three research themes share nearly similar weights: engineering epistemologies (31/437=7%), engineering diversity and inclusiveness (32/437=7%), and engineering assessment (34/437=8%). From an annual-analysis perspective, the number of articles classified in engineering learning mechanisms and systems decreases significantly.

In the category of engineering epistemologies, an increasing number of articles centre in the most recent two years (2008 and 2009). In the category of engineering diversity and inclusiveness, the number of articles published in the most three years (2007 to 2009) is almost half of the total number from all ten years. In the category of engineering assessment, a limited number of articles were published in the most recent four years (2006 to 2009).

As shown in Table 10, for each research theme, competency analysis in engineering epistemologies (13/31=42%), instructional design in engineering learning mechanisms (133/211=63%), curriculum issues in engineering learning systems (54/129=42%), gender issues in engineering diversity and inclusiveness (13/32=41%), and assessment methods in engineering assessment (25/34=74%) are major research topics. However, topics related to distance learning in

engineering learning mechanisms (16/211=7%) are unpopular in the JEE. Consequently, on-line learning (or e-learning), apparently, was not a developmental focus in engineering educational research during the past ten years.

SSCI for Analysis

The information of the Top 10 most frequently cited articles is summarised in Table 11. Table 12 specifies these frequently cited articles with details of research titles. Apparently, all top, frequently cited articles in the JEE are theoretical-inquiry studies. This finding indicates that conceptual ideas in engineering education are journal contributors' preferences.

An intriguing point is that eight of ten articles were published in 2005 (Vol. 94, No.1). In the category of research theme, most articles centred on engineering learning mechanisms. Topics in engineering epistemologies received no attention.

Table 11: Summary of SSCI analysis.

| Article Information | Research Method | Research Subject | Engineering Discipline | Research Theme | Citation Count |
|---|---|---|---|---|---|
| Prince (2004) Vol.93, No.3 | Theoretical inquiry | None | None | Engineering learning mechanisms | 76 |
| Felder & Brent (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering learning mechanisms | 57 |
| Shuman et al (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering learning mechanisms | 52 |
| Smith et al (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering learning mechanisms | 50 |
| Feisel & Rosa (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering learning mechanisms | 37 |
| Prince & Felder (2006) Vol.95, No.2 | Theoretical inquiry | None | None | Engineering learning mechanisms | 27 |
| Olds, et al (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering assessment | 26 |
| Bourne, et al (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering learning mechanisms | 20 |
| Chubin, et al (2005) Vol.94, No.1 | Theoretical inquiry | None | None | Engineering diversity and inclusiveness | 18 |
| Prados, et al (2005) Vol. 94, No.1 | Theoretical inquiry | None | None | Engineering learning systems | 17 |

*The time end-point for data retrieval was December (12/31) 2009.

Table 12: Frequently cited articles with research title.

| Author | Research Title |
|---|---|
| Prince (2004) | Does active learning work? A review of the research. |
| Felder & Brent (2005) | Understanding student differences. |
| Shuman et al (2005) | The ABET professional skills: Can they be taught? Can they be assessed? |
| Smith et al (2005) | Pedagogies of engagement: Classroom-based practices. |
| Feisel & Rosa (2005) | The role of the laboratory in undergraduate engineering education. |
| Prince & Felder (2006) | Inductive teaching and learning methods: definitions, comparisons, and research bases. |
| Olds, et al (2005) | Assessment in engineering education: Evolution, approaches and future collaborations. |
| Bourne, et al (2005) | Diversifying the engineering workforce. |
| Chubin, et al (2005) | Quality assurance of engineering education through accreditation: The impact of engineering criteria 2000 and its global influence. |

Author's Geographical Affiliation for Analysis

The information regarding the first author's geographical affiliation from JEE articles in the past ten years appears in Table 13. The frequency analysis indicates that the United States of America is a major country of affiliation for the first author (406/437=93%).

The total number of scholars in other countries is less than 10% (31/437=7%), of which Canadian scholars are major contributors (10/31=33%). This finding shows that the majority of JEE contributors come from North America (416/437=95%), and suggests that more effort needs to be focused on internationalisation of engineering education research.

Table 13: The first author's geographical affiliation from JEE articles*.

| Area | Frequency by country |
|---|---|
| North America | United States of America (406), Canada (10) |
| South America | Portugal (1) |
| Europe | Spain (2), England (2), Sweden (2), Greece (1), Norway (1) |
| Middle East | Israel (2), Kuwait (1), Pakistan (1) |
| Asia-Pacific | Taiwan (2), Hong Kong (1), South Korea (1) |
| South Asia | Australia (1), New Zealand (1) |
| Africa | South Africa (2) |

*Frequency by country is in parentheses

Keywords for Analysis

Results of keyword frequency listed in JEE articles from 2004 to 2009 appear in Table 14. In addition to years 2004 and 2007, the most frequently used keyword in 2005, 2006, and 2008 is *assessment*; in 2009, *gender*. In 2004, three keywords share the same frequency: *assessment*, *problem-based learning*, and *collaborative learning*. However, because one research team produced two similar articles in 2007, keywords, *cognitive processing*, *instructional software* and *skill development* appeared twice from those articles. In total, *assessment* (15), *engineering ethics* (5), *problem-based learning* (4) and *problem-solving* (4) were the most frequently used keywords in JEE articles in the past 6 years.

Table 14: Keyword frequencies in JEE from 2004 to 2009*.

| Year | Frequency by keyword |
|---|---|
| 2004 | Assessment (2), Problem-based learning (2), Collaborative learning (2) |
| 2005 | Assessment (5), Engineering ethics (2), On-line education (2)<br>Learning style (2), Problem-based learning (2), Engineering education (2) |
| 2006 | Assessment (5), Engineering ethics (3), Problem-solving (2), How people learn (2) |
| 2007 | Cognitive processing (2), Instructional software (2), Skill development (2) |
| 2008 | Assessment (3), Self-efficacy (2) Problem-solving (2), Epistemology (2) |
| 2009 | Gender (3), Qualitative research (2), Women in engineering (2) |

*Keyword frequency is in parentheses

Summary of the major findings yielded by the data analysis:

1. The majority of JEE articles in the past ten years followed quantitative-based research design.
2. The majority of quantitative studies used a survey methodology as a primary research method, in the past ten years.
3. More than half of quantitative studies contained descriptive and inferential statistics when reporting research findings, in the past ten years.
4. More than half of qualitative studies employed the interview technique to collect data, in the past ten years.
5. Seventy-five percent of research participants in JEE articles were college students, in the past ten years.
6. The primary focus of all research papers was on engineering learning mechanisms and engineering learning systems, in the past ten years.
7. Top three engineering disciplines discussed in the JEE are mechanical engineering, electrical and computer engineering and civil engineering.
8. All most frequently cited articles in the JEE from 2004 to 2009 are theoretical-inquiry studies.
9. The majority of JEE contributors come from North America.
10. Assessment, engineering ethics, problem-based learning and problem-solving were the most frequently used keywords in JEE articles from 2004 to 2009.

## CONCLUSIONS

The present study adds insight into knowledge bases of current engineering educational research. Through a decade-review process, seven analytical approaches: characteristics of research methods, research subject, engineering discipline, research topic, citation information, author's geographical affiliation and article keywords, produced ten major findings.

Based on the findings, several suggestions for engineering education researchers are proposed. First, the qualitative research design is still a less frequent methodology. In an effort to balance the dominance of quantitative-based papers, engineering education researchers must be self-motivated to submit high-quality qualitative-based manuscripts to any publications in the field of engineering education. Second, the findings show that most articles did not specify research participants' engineering disciplines. To allow readers to obtain a thorough understanding of research procedures, engineering education researchers must identify their engineering disciplines in detail. Third, the number of articles that appear in the categories of engineering epistemology, engineering diversity and inclusiveness, and engineering

assessment is limited. To promote academic diversity, engineering educators may concentrate more efforts on those three categories. Fourth, while conducting the engineering education research, most researchers tend to select college students as research participants. To attract more attention from K-12 educators and students, engineering education researchers should extend their research scope to high schools and elementary schools.

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