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RESEARCH REPORT

Research Trends in Science Education from 2003 to 2007: A content analysis of publications in selected journals

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The present study was a follow-up to Tsai and Wen's (2005) earlier research, in which 802 articles published in the *International Journal of Science Education*, *Science Education*, and the *Journal of Research in Science Teaching* from 1998 to 2002 were analysed in terms of author's nationality, research type, and research topic. In the present study a total of 869 papers published in the three journals from 2003 to 2007 were analysed, and the results were compared with those of Tsai and Wen. Moreover, this study also identified 31 highly-cited papers published during 1998–2002 and 20 highly-cited papers published during 2003–2007. The results showed that authors from countries other than the four major English-speaking countries (i.e., the USA, the UK, Australia, and Canada) published an increasing number of articles in the past decade. During these five years (2003–2007), science educators showed relatively more interest in research topics involving the context of student learning. Besides, science educators have changed some of their research interests during 1998–2007, with a shift in the research topics from student conception learning and conceptual change (1998–2002) to student learning contexts (2003–2007). Moreover, the investigation of highly-cited papers in the past decade revealed that studies on argumentation have gained significant attention among science educators.

Introduction

For researchers, information about the current status and trends of research in their fields is helpful for their career and academic publications. As Tsai and Wen (2005) stated, 'writing for publication' is always one of the major tasks for researchers. Henson (1997, 1999, 2001) also suggested that, on the one hand, the research findings can be widely recognised in the academic community through publications,

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and on the other hand, the researchers can advance their own careers by applying for tenure, promotion, grants, or scholar awards. To this end, systematic content analyses of articles published in related academic journals, such as content analysis and citation analysis, have been conducted in many research fields, such as psychology (e.g., Howard, Cole, & Maxwell, 1987; Smith, et al., 1998), science education (e.g., Eybe & Schmidt, 2001; Rennie, 1998; Tsai & Wen, 2005), instructional technology and e-learning (e.g., Shih, Feng, & Tsai, 2008), management (e.g., Pilkington & Chai, 2008), and business (e.g., Ki & Shin, 2006).

In the field of science education, there has already been some systematic investigation of the research papers published in academic journals (Eybe & Schmidt, 2001; Rennie, 1998; Tsai & Wen, 2005). However, the information provided by these reports may not be sufficiently up-to-date for the research community today. Recently, Tsai and Wen (2005) explored the research trends in science education from 1998 to 2002 through content analysis of a total of 802 research articles published in the three most important journals of science education: the *International Journal of Science Education* (IJSE), *Science Education* (SE), and the *Journal of Research in Science Teaching* (JRST). They revealed some findings about research trends in science education from 1998 to 2002. For example, the research topic of students' conceptions and conceptual change was the most frequently investigated topic in this period; however, a declining trend was observed when analysed by year. They also suggested that the research topics related to student learning context, and social, cultural, and gender issues were gradually gaining more attention among science education researchers. Furthermore, as stated by Jenkins (2000) and Tsai and Wen (2005), researchers from a greater variety of countries have gradually begun to contribute to the field of science education research, thus introducing obvious diversity into the field. The diversity of nationality of researchers may lead to variations in the methodologies used and the research topics chosen for exploration. Tsai and Wen (2005) also suggested that a systematic investigation of the nationality of authors who contribute to academic research, and a careful analysis of the research types and topics currently published by major journals, may provide more information about the growing internationalisation in this field and be beneficial to contemporary science educators by enabling them to examine research trends.

Therefore, to provide deeper insights into research trends within a longer period, a follow-up study concerning nationality of author, research type, and research topic, as suggested by Tsai and Wen (2005), may be helpful. The findings derived from these two studies can then be compared and integrated, and research trends during the recent decade in science education can possibly be revealed. To this end, the present study analysed all of the articles published in IJSE, SE, and JRST during 2003–2007, and further compared the results of this study and those of Tsai and Wen (2005). Although *Research in Science Education* has also listed in the Social Sciences Citation Index since 2003, for the comparison with previous work (Tsai & Wen, 2005; a review for papers from 1998 to 2002), we did not include *Research in Science Education* in this review. Furthermore, it has been advocated that the impact

of published articles can be further evaluated using the citation counts of each article (Garfield, 1972; Harter & Nisonger, 1997). Shih et al. (2008) also suggested that the analysis of highly-cited articles may help researchers to recognise more influential works in studied areas. The articles with more citation frequencies are generally those that are better acknowledged by others in related fields, and probably present more innovation in terms of issues for further research (Shih et al., 2008). Thus, in advance of Tsai and Wen (2005), the present study further analysed the highly-cited papers published in the three journals in the two periods 1998–2002 and 2003–2007.

In sum, the current study addresses the following research questions:

1. How did authors from different countries contribute to the publications of these selected journals from 2003 to 2007?
2. How did the types of articles published in the three journals vary across these five years (2003–2007)?
3. How did the topics of the published papers in the three journals vary across these five years (2003–2007)?
4. How did the research trends, including country contribution, research type, and research topic of the articles published in the journals vary from 1998 to 2007?
5. How did the research trends of highly-cited research articles published in the journals vary from 1998 to 2007?

Method

One of the major purposes of this study was to compare the results with those of Tsai and Wen (2005). Therefore, the coding methods in Tsai and Wen (2005), including author nationality, research type, and research topic, were replicated in this study. Detailed descriptions of these coding methods are available in Tsai and Wen (2005), and are briefly described as follows.

Research Papers for Analysis

Following Tsai and Wen's (2005) study, the present study used all of the papers published in IJSE, SE, and JRST from 2003 to 2007 (five years) as the research sample to examine the research trends in science education. The papers that fall into the categories of 'editorial', 'commentary', 'responses', and 'book reviews' were excluded from the analysis, leaving a total of 869 articles to be analysed.

Authors' Nationality

The research contribution by each country was analysed quantitatively and ranked for these three journals within the five years. The quantitative ranking method followed the formula of Howard et al. (1987) and the study of Tsai and Wen (2005). This formula was conformed to the basis of number and order of authorship

(Howard et al., 1987). It is believed that this formula can represent the contribution of each author in a multi-authored paper in a relatively neutral manner. Accordingly, each paper was given one point. If a paper was published by authors from different countries, the following formula was used to calculate the score (Howard et al., 1987; Tsai & Wen, 2005):

$$score = \frac{(1.5^{n-i})}{\sum_{i=1}^{n} 1.5^{n-i}}$$

where n is the total number of authors, and i is the order of the specific author. For example, if a paper has two authors, the first British and the second Taiwanese, then for this particular paper the UK will get a score of 0.6 while Taiwan will acquire a score of 0.4. The detailed score allocation derived from this formula can be referred to in Tsai and Wen (2005). Accordingly, the accumulated score for each country was calculated and compared by year and by journal.

Research Type

The classification of research type followed Tsai and Wen's (2005) study in that each published article was categorised into one of the following five categories: (1) empirical research article, such as quantitative and qualitative research; (2) position paper (i.e., one holding a specific position for a certain issue of science education); (3) theoretical paper (i.e., one proposing a new theory or theoretical framework in the field of science education); (4) review (i.e., a paper summarising the research literature without proposing a strong position); and (5) other (e.g., a description of the science curricula of a specific country). The papers were categorised by two researchers (one a doctoral candidate and the other an assistant professor in science education) with an agreement of 0.99, and those that were categorised differently were further discussed with a professor in science education and categorised with agreement. The frequencies of each category were calculated for analysis.

Research Topic

In this study, the researchers categorised the research topic of each published article into one of the following nine categories, which were mainly adapted from the National Association for the Research in Science Teaching Conference strand categories around the years of 2000–2003, exactly the same as in Tsai and Wen's (2005) study: (1) Teacher Education; (2) Teaching; (3) Learning—Conceptions; (4) Learning—Contexts; (5) Goals and Policy; (6) Culture, Social, and Gender issues; (7) History, Philosophy, Epistemology, and Nature of Science; (8) Educational

Technology; and (9) Informal Learning. The categories with some typical topics are listed below (Tsai & Wen, 2005):

1. *Teacher education:* Preservice and continuing professional development of teachers; teacher education programmes and policy; field experience; issues related to teacher education reform.
2. *Teaching:* Teacher cognition; pedagogical knowledge and pedagogical content knowledge; forms of knowledge representation; exemplary teachers; teacher thinking; teaching behaviours and strategies.
3. *Learning—students' conceptions and conceptual change (Learning—conception):* Methods for investigating student understanding; students' alternative conceptions; instructional approaches for conceptual change; conceptual change in learners; conceptual development.
4. *Learning—classroom contexts and learner characteristics (Learning—context):* Student motivation; learning environment; individual differences; reasoning; learning approaches; exceptionality; teacher–student interactions; peer interactions; laboratory environments; affective dimensions of science learning; cooperative learning; language, writing and discourse in learning; social, political, and economic factors.
5. *Goals and policy, curriculum, evaluation, and assessment:* Curriculum development, change, implementation, dissemination and evaluation; social analysis of curriculum; alternative forms of assessment; teacher evaluation; educational measurement; identifying effective schools; curriculum policy and reform.
6. *Cultural, social and gender issues:* Multicultural and bilingual issues; ethnic issues; gender issues; comparative studies; issues of diversity related to science teaching and learning.
7. *History, philosophy, epistemology and nature of science:* Historical issues; philosophical issues; epistemological issues; ethical and moral issues; nature of science.
8. *Educational technology:* Computers; interactive multimedia; video; integration of technology into teaching; learning and assessment involving the use of technology.
9. *Informal Learning:* Science learning in informal contexts (e.g., museums, outdoor settings, etc.); public awareness of science.

The two researchers classified each research paper into one (and only one) *best-fit* category among the nine categories above. The categorisation process resulted in an agreement of 0.91, and disagreements were solved upon discussion with a professor in science education. The frequencies of each topic category were calculated for analysis.

Highly-cited Papers

In this study, the highly-cited papers were identified via the following steps. First, we counted the number of times each paper published in IJSE, SE, and JRST during 1998–2007 that been cited *per year* (as at February 29, 2008) using the database of

the Social Sciences Citation Index. Secondly, this study chose the top 3% of papers based on the above citation counts. As a result, a total of 51 papers were selected, each of which was cited at least four times per year. According to the impact factor in IJSE, SE, and JRST of 2006 as released by the Institute for Scientific Information *Journal Citation Reports*, each article from the three journals has been cited on average about 0.815 times in 2006. Consequently, the 51 papers (31 articles in the period 1998–2002 and 20 articles in the period 2003–2007) selected by the above steps can be identified as highly-cited papers. Several indicators including research type, research topic, and research method (only empirical studies) are utilised to analyse these highly-cited papers. In addition, to further provide researchers with an opportunity to understand the most influential works and individuals in science education, this study additionally analysed the 10 most frequently cited papers in 1998–2002 and in 2003–2007. These highly-cited papers are listed in the Appendix.

Results

In this study, all of the published papers in IJSE, SE, and JRST were analysed by authors' nationality, research type, and research topic. The results above were then compared with those in Tsai and Wen (2005), in which all the articles published in IJSE, SE, and JRST during 1998–2002 were analysed. Finally, the present study further identified highly-cited papers published in the three journals during 1998–2002 and 2003–2007. Therefore, the results of this study consist of the following three major parts: analyses of published papers during the years 2003–2007, comparisons of published articles between 1998–2002 and 2003–2007, and analyses of highly-cited papers.

Analyses of Published Papers during 2003–2007

Published paper by authors' nationality. To analyse the research contribution by country, each paper published in IJSE, SE, and JRST during 2003–2007 was given one point. The papers with multiple authors from different countries were scored by the formula proposed by Howard et al. (1987). As shown in Table 1, when analysed by year, the USA and the UK were consistently the two countries with the most frequent authors, with higher scores from 2003 to 2007. When analysed by the total scores from 2003 to 2007, the USA, the UK, Australia, and Canada were the top four countries. Nevertheless, it is interesting to find that Taiwan had almost the same score as Canada in the period 2003–2007 (43.68 versus 42.04). Table 2 reveals that, for IJSE, authors from the UK, the USA, and Australia published most. For SE, most authors came from the USA, Canada, and the UK, while in JRST authors from the USA, Israel, and Canada had more publications. Similar to the findings in Tsai and Wen (2005), researchers from English-speaking countries also contributed most to these three journals during 2003–2007.

As aforementioned, when analysing the research contribution by country, the USA, the UK, Australia, and Canada had higher total country scores from 2003 to

Table 1. Country ranks of publications from 2003 to 2007 (top 10) for the three journals (IJSE, SE, and JRST)

	2003–2007		2003		2004		2005		2006		2007	
Rank	Country	Score	Country	Score	Country	Score	Country	Score	Country	Score	Country	Score
1	USA	356.82	USA	69.78	USA	69.23	USA	60.75	USA	67.42	USA	89.64
2	UK	92.28	UK	13.73	UK	22.85	UK	14.31	UK	23.89	UK	17.50
3	Australia	50.02	Australia	9.55	Australia	14.14	Taiwan	11.47	Canada	9.4	Taiwan	14.37
4	Canada	43.68	Israel	6.41	Canada	11.23	Israel	10.78	Australia	8.73	Canada	9.56
5	Taiwan	42.04	Canada	6.28	Israel	8.03	Australia	9.92	Israel	8.01	Australia	7.68
6	Israel	38.64	Taiwan	5.60	Taiwan	5.61	New Zealand	8.00	Netherlands	7.44	Spain	7.00
7	Spain	28.79	Germany	5.47	Greece	5.40	Canada	7.21	Spain	5.00	Israel	5.41
8	Netherlands	21.24	Spain	4.79	Spain	5.00	Spain	7.00	Taiwan	4.99	South Africa	5.00
9	Turkey	16.67	New Zealand	3.73	Netherlands	5.00	Netherlands	6.59	Turkey	4.75	Turkey	4.77
10	South Africa	15.16	South Africa	3.2	France	4.68	Sweden	4.20	Greece	4.00	Sweden	4.00

Table 2. Country ranks and percentages of publications in individual journals from 2003 to 2007 (top 10)

	IJSE (n = 404)		SE (n = 223)		JRST (n = 242)	
Rank	Country	Score	Country	Score	Country	Score
1	UK	76.19 (18.9%)	USA	119.12 (53.4%)	USA	162.70 (67.2%)
2	USA	75.00 (18.6%)	Canada	20.82 (9.3%)	Israel	14.38 (5.9%)
3	Australia	31.69 (7.8%)	UK	11.69 (5.2%)	Canada	11.27 (4.7%)
4	Taiwan	30.25 (7.5%)	Israel	10.75 (4.8%)	Australia	9.13 (3.8%)
5	Netherlands	18.24 (4.5%)	Spain	9.68 (4.3%)	Turkey	5.00 (2.1%)
6	Spain	17.79 (4.4%)	Australia	9.20 (4.1%)	Taiwan	4.79 (2.0%)
7	Israel	13.51 (3.3%)	Taiwan	7.00 (3.1%)	UK	4.40 (1.8%)
8	France	11.89 (2.9%)	Greece	5.00 (2.2%)	Germany	3.66 (1.5%)
9	Canada	11.59 (2.9%)	Sweden	4.07 (1.8%)	South Africa	2.70 (1.1%)
10	New Zealand	11.20 (2.8%)	South Africa	3.00 (1.3%)	Netherlands	2.40 (1.0%)

2007. To further examine the publication of authors from non-English-speaking countries, the nationality of authors was categorised into five groups: the USA, the UK, Australia, Canada, and other (many of which are non-English-speaking) countries. The results in Table 3 show that authors from these four English-speaking countries (i.e., the USA, the UK, Australia, and Canada) contributed over one-half of the publications in the three journals from 2003 to 2007. These four English-speaking countries contributed 72% of the articles in SE and 77.5% in JRST during these five years; however, they only contributed 48.2% in IJSE (see Table 4). Clearly, compared with the other two journals, IJSE published relatively more papers written by authors from diverse non-English-speaking countries during the years 2003–2007.

Published papers by research type. According to their research type, all the papers published in the three journals during 2003–2007 are categorised into five categories: empirical research article, position paper, theoretical paper, review, and other. The trends of the research types from 2003 to 2007 are presented in Table 5. As shown in Table 5, the empirical research article, ranging from 85% to 92.5%, was the major type of publication within these five years.

In addition, the trends of the research types from 2003 to 2007 were also analysed by journal. Table 6 shows that, for all three journals, empirical studies were the most published. In particular, almost 98% of papers published in JRST were empirical research articles. Comparatively, SE published relatively more position papers as well as relatively more theoretical papers than the other two journals.

Published papers by research topic. As shown in Table 7, within these five years the three journals published most papers regarding Learning—Contexts (23.5%), followed by Learning—Conceptions (15.3%) and Teaching (13.9%). Besides, the

Table 3. Country ranks and percentages of publications from 2003 to 2007 (top five groups) for the three journals (IJSE, SE, and JRST)

2003–2007 (n = 869)		2003 (n = 154)		2004 (n = 187)	
Country	Score (%)	Country	Score (%)	Country	Score (%)
USA	356.82 (41.1%)	USA	69.78 (45.3%)	USA	69.23 (37.0%)
UK	92.28 (10.6%)	UK	13.73 (8.9%)	UK	22.85 (12.2%)
Australia	50.02 (5.8%)	Australia	9.55 (6.2%)	Australia	14.14 (7.6%)
Canada	43.68 (5.0%)	Canada	6.28 (4.1%)	Canada	11.23 (6.0%)
Others	326.2 (37.5%)	Others	54.66 (35.5%)	Others	69.55 (37.2%)

Table 3. *(Continued)*

2005 (n = 176)		2006 (n = 165)		2007 (n = 187)	
Country	Score (%)	Country	Score (%)	Country	Score (%)
USA	60.75 (34.5%)	USA	67.42 (40.9%)	USA	89.64 (47.9%)
UK	14.31 (8.1%)	UK	23.89 (14.5%)	UK	17.5 (9.4%)
Australia	9.92 (5.6%)	Australia	8.73 (5.3%)	Australia	7.68 (4.1%)
Canada	7.21 (4.1%)	Canada	9.4 (5.7%)	Canada	9.56 (5.1%)
Others	83.81 (47.6%)	Others	55.56 (33.7%)	Others	62.62 (33.5%)

Table 4. Country ranks and percentages of publications in individual journals (top five groups) from 2003 to 2007

IJSE (n = 404)		SE (n = 223)		JRST (n = 242)	
Country	Score	Country	Score	Country	Score
USA	75.00 (18.6%)	USA	119.12 (53.4%)	USA	162.70 (67.2%)
UK	76.19 (18.9%)	UK	11.69 (5.2%)	UK	4.40 (1.8%)
Australia	31.69 (7.8%)	Australia	9.20 (4.1%)	Australia	9.13 (3.8%)
Canada	11.59 (2.9%)	Canada	20.82 (9.3%)	Canada	11.27 (4.7%)
Others	209.53 (51.8%)	Others	62.17 (28.0%)	Others	54.5 (22.5%)

Table 5. Frequencies and percentages of research types from 2003 to 2007 for the three journals (IJSE, SE, and JRST)

Research type	2003–2007	2003 (n = 154)	2004 (n = 187)	2005 (n = 176)	2006 (n = 168)	2007 (n = 187)
Empirical	763 (87.8%)	135 (87.7%)	159 (85.0%)	153 (86.9%)	143 (86.7%)	173 (92.5%)
Position	36 (4.1%)	6 (3.9%)	13 (7.0%)	5 (2.8%)	6 (3.6%)	6 (3.2%)
Theory	30 (3.5%)	6 (3.9%)	9 (4.8%)	8 (4.5%)	4 (2.4%)	3 (1.6%)
Review	26 (3.0%)	5 (3.2%)	5 (2.7%)	7 (4.0%)	5 (3.0%)	4 (2.1%)
Other	14 (1.6%)	2 (1.3%)	1 (0.5%)	3 (1.7%)	7 (4.2%)	1 (0.5%)

Table 6. Frequencies and percentages of research types in individual journals from 2003 to 2007

Research type	IJSE (n = 404)	SE (n = 223)	JRST (n = 242)
Empirical	351 (86.9%)	175 (78.5%)	237 (97.9%)
Position	15 (3.7%)	20 (9.0%)	1 (0.4%)
Theory	12 (3.0%)	16 (7.2%)	2 (0.8%)
Review	18 (4.5%)	7 (3.1%)	1 (0.4%)
Other	8 (2.0%)	5 (2.2%)	1 (0.4%)

category Learning–Contexts consistently ranked in the top two topics from 2003 to 2007. In other words, within these five years science educators were highly interested in Learning-Contexts topics, such as learning environment, reasoning, and the affective dimensions of science learning. It should also be noted that researchers in science education also displayed considerable interest in research regarding Learning—Conceptions, Teaching and Goals, Policy, and Curriculum, with the percentage of total papers published during 2003–2007 for each topic being 15.3%, 13.9%, and 12.7%, respectively.

When comparing the results presented in Table 5 with those in Table 7, the empirical paper was still the major type of publications across various research topics within these five years. Furthermore, this study preliminarily cross-analysed the

Table 7. Frequencies and percentages of research topics from 2003 to 2007 for the three journals (IJSE, SE, and JRST)

Research topic	2003–2007	2003 (n = 154)	2004 (n = 187)	2005 (n = 176)	2006 (n = 168)	2007 (n = 187)
Teacher Education	78 (9.0%)	12 (7.8%)	16 (8.6%)	23 (13.1%)	10 (6.1%)	17 (9.1%)
Teaching	121 (13.9%)*	15 (9.7%)	29 (15.5%)**	30 (17.0%)**	22 (13.3%)*	25 (13.4%)*
Learning—Conception	133 (15.3%)**	32 (20.8%)***	28 (15.0%)*	23 (13.1%)	23 (13.9%)**	27 (14.4%)**
Learning—Contexts	204 (23.5%)***	30 (19.5%)**	38 (20.3%)***	41 (23.3%)***	50 (30.3%)***	45 (24.1%)***
Goals, Policy, and Curriculum	110 (12.7%)	19 (12.3%)*	22 (11.8%)	24 (13.6%)*	22 (13.3%)*	23 (12.3%)
Culture, Social and Gender	59 (6.8%)	10 (6.5%)	14 (7.5%)	11 (6.3%)	11 (6.7%)	13 (7.0%)
Philosophy, History, and Nature of Science	71 (8.2%)	16 (10.4%)	18 (9.6%)	10 (5.7%)	14 (8.5%)	13 (7.0%)
Educational Technology	47 (5.4%)	14 (9.1%)	11 (5.9%)	10 (5.7%)	6 (3.6%)	6 (3.2%)
Informal Learning	46 (5.3%)	6 (3.9%)	11 (5.9%)	4 (2.3%)	7 (4.2%)	18 (9.6%)

Note: ***Top one topic, **top two topic, *top three topic.

research type and topic of publications within these five years, and found that the research topic regarding Goals, Policy, and Curriculum published relatively more non-empirical papers than other research topics. This implies that the research regarding Goals, Policy, and Curriculum may aim to discuss some fundamental ideas or contemporary status regarding the goals, policy and curriculum in science education and it may not necessarily conduct an empirical study.

In addition, the research topics were also examined by journal. Table 8 shows that, across the three journals, the highest percentage of articles published during 2003–2007 were related to the category Learning—Contexts. Moreover, the category of Learning—Conceptions consistently ranked as one of the top three topics in IJSE, SE, and JRST. However, there are still some differences in the preferences for topics across the journals. IJSE published a relatively higher percentage of papers regarding Teaching (15.8%), while the other two journals (i.e., SE and JRST) published more articles regarding Goals, Policy, and Curriculum (14.8% in SE and 12.8% in JRST).

Comparisons of Published Articles between 1998–2002 and 2003–2007

To provide deeper insights into the research trends in contemporary science education, this study further compared the articles published in the three journals during 1998–2002 and those during 2003–2007.

Comparisons of authors' nationality. In line with their performance during the five years 1998–2002, the USA, the UK, Australia, and Canada were still the top four countries with higher scores during 2003–2007 (Table 9). These four English-speaking countries contributed a major proportion of academic publications in the past decade.

The results in Table 10 show that, perhaps due to the language used, the four English-speaking countries—the USA, the UK, Australia, and Canada—contributed most to the three journals during the five years 1998–2002 (71.7% of total score) as

Table 8. Frequencies and percentages of research topics in individual journals from 2003 to 2007

	IJSE (n = 404)	SE (n = 223)	JRST (n = 242)
Teacher Education	22 (5.4%)	27 (12.1%)	29 (12.0%)
Teaching	64 (15.8%)*	28 (12.6%)	29 (12.0%)
Learning—Conception	70 (17.3%)**	33 (14.8%)**	30 (12.4%)*
Learning—Contexts	106 (26.2%)***	43 (19.3%)***	55 (22.7%)***
Goals, Policy, and Curriculum	46 (11.4%)	33 (14.8%)**	31 (12.8%)**
Culture, Social and Gender	21 (5.2%)	12 (5.4%)	26 (10.7%)
Philosophy, History, and Nature of Science	30 (7.4%)	22 (9.9%)	19 (7.9%)
Educational Technology	26 (6.4%)	6 (2.7%)	15 (6.2%)
Informal Learning	19 (4.7%)	19 (8.5%)	8 (3.3%)

Top one topic***, top two topic**, top three topic*

Table 9. Comparisons of country ranks of publications between 1998–2002 and 2003–2007 (top 10) for the three journals (IJSE, SE, and JRST)

	1998–2002		2003–2007	
Rank	Country	Score	Country	Score
1	USA	346.35	USA	356.82
2	UK	121.76	UK	92.28
3	Australia	69.18	Australia	50.02
4	Canada	37.48	Canada	43.68
5	Israel	29.75	Taiwan	42.04
6	Spain	24.20	Israel	38.64
7	Taiwan	20.40	Spain	28.79
8	South Africa	14.68	Netherlands	21.24
9	Netherlands	14.47	Turkey	16.67
10	Germany	12.08	South Africa	15.16

Table 10. Comparisons of country ranks and percentages of publications between 1998–2002 and 2003–2007 (top five groups) for the three journals (IJSE, SE, and JRST)

1998–2002 (n = 802)		2003–2007 (n = 869)	
Country	Score (%)	Country	Score (%)
USA	346.35 (43.2%)	USA	356.82 (41.1%)
UK	121.76 (15.2%)	UK	92.28 (10.6%)
Australia	69.18 (8.6%)	Australia	50.02 (5.8%)
Canada	37.48 (4.7%)	Canada	43.68 (5.0%)
Others	227.23 (28.3%)	Others	326.2 (37.5%)

well as during the recent five years 2003–2007 (62.5% of total score). However, compared with their performance from 1998 to 2002 (28.3% of total score), other countries (mostly non-English-speaking) had increasing numbers of contributions during 2003–2007 (37.5% of total score). It seems that non-English-speaking countries have displayed their increasing research contributions in the past five years. In other words, more and more authors from diverse language-speaking countries are contributing to the science research community.

Comparisons of research type. As shown in Table 11, the empirical study was the major research type of publication from 1998 to 2002 (86.9%) as well as from 2003 to 2007 (87.8%) in the science education community.

Comparisons of research topic. As revealed in Table 12, the topics Learning—Conceptions and Learning—Context ranked in the top two both in 1998–2002

Table 11. Comparisons of frequencies and percentages of research types between 1998–2002 and 2003–2007 for the three journals (IJSE, SE, and JRST)

	1998–2002	2003–2007
Empirical	697 (86.9%)	763 (87.8%)
Position	75 (9.4%)	36 (4.1%)
Theory	6 (0.7%)	30 (3.5%)
Review	13 (1.6%)	26 (3.0%)
Other	11 (1.4%)	14 (1.6%)

Table 12. Comparisons of frequencies and percentages of research topics between 1998–2002 and 2003–2007 for the three journals (IJSE, SE, and JRST)

	1998–2002 (n = 802)	2003–2007 (n = 869)
Teacher Education	55 (6.9%)	78 (9.0%)
Teaching	53 (6.6%)	121 (13.9%)*
Learning—Conception	198 (24.8%)***	133 (15.3%)**
Learning—Contexts	143 (17.9%)**	204 (23.5%)***
Goals, Policy, and Curriculum	109 (13.7%)	110 (12.7%)
Culture, Social and Gender	115 (14.4%)*	59 (6.8%)
Philosophy, History, and Nature of Science	68 (8.5%)	71 (8.2%)
Educational Technology	27 (3.4%)	47 (5.4%)
Informal Learning	30 (3.8%)	46 (5.3%)

Note: ***Top one topic, **top two topic, *top three topic.

(24.8% and 17.9%, respectively) and in 2003–2007 (15.3% and 23.5%, respectively). In addition, Culture, Social and Gender (14.4%) was the third-ranked research topic in 1998–2002, while Teaching (13.9%) was the third-ranked research topic in 2003–2007. During 1998 to 2007, a clearly increasing trend was found in Learning—Context (from 17.9% to 23.5%) and Teaching (from 6.6% to 13.9%), while a declining trend was revealed for Learning—Conceptions (from 24.8% to 15.3%) and Culture, Social and Gender (from 14.4% to 6.8%). Clearly, science educators have shifted their research foci during these 10 years.

Analyses of Highly-cited Papers

This study further identified 31 highly-cited papers in the three journals in 1998–2002 and 20 highly-cited articles in 2003–2007. The 10 most frequently cited papers of 1998–2002 and of 2003–2007 are presented in the Appendix.

Highly-cited papers by research type. Table 13 shows that most of the highly-cited papers in 1998–2002 (48.4%) as well as in 2003–2007 (60.0%) were empirical

Table 13. Comparisons of research types of highly-cited articles between 1998–2002 and 2003–2007

	1998–2002 (n = 31)	2003–2007 (n = 20)
Empirical	15 (48.4%)	12 (60.0%)
Position	4 (12.9%)	2 (10.0%)
Theory	4 (12.9%)	1 (5.0%)
Review	6 (19.4%)	4 (20.0%)
Other	2 (6.5%)	1 (5.0%)

studies. It should be noted that around 87% of papers published in 1998–2002 as well as 2003–2007 were categorised as empirical studies (see Table 11), but only 48.4% and 60%, respectively, of highly-cited papers are empirical research. Among highly-cited empirical studies in 1998–2002 (n = 15), two-thirds of them were qualitative studies (n = 10) and all the others were mixed-method studies (i.e., using both quantitative and qualitative research methods, n = 5). Moreover, three-quarter of the highly-cited empirical papers in 2003–2007 were conducted qualitatively (n = 9), and all the other highly-cited empirical papers were conducted using mixed methods (n = 3). This implies that qualitative studies may have more impact on research in the field of science education. In general, qualitative research is used to discover themes and relationships at the case level, and plays a discovery role (Gall, Gall, & Borg, 2003, p. 24). Thus, qualitative research may present more fundamental ideas about contemporary issues, and is better recognised by others in related fields.

Highly-cited papers by research topic. As revealed in Table 14, the top three topics of highly-cited papers in 1998–2002 were Learning—Context (19.4%), Goals, Policy, Curriculum (19.4%), and Philosophy, History and Nature of Science (16.1%), while those in 2003–2007 were Learning—Context (40%), Goals, Policy,

Table 14. Comparisons of research topics of highly-cited articles between 1998–2002 and 2003–2007

	1998–2002 (n = 31)	2003–2007 (n = 20)
Teacher Education	3 (9.7%)	3 (15.0%)**
Teaching	3 (9.7%)	0 (0.0%)
Learning—Conception	2 (6.5%)	1 (5.0%)
Learning—Contexts	6 (19.4%)***	8 (40.0%)***
Goals, Policy, and Curriculum	6 (19.4%)***	3 (15.0%)**
Culture, Social and Gender	4 (12.9%)	1 (5.0%)
Philosophy, History, and Nature of Science	5 (16.1%)**	2 (10.0%)
Educational Technology	2 (6.5%)	2 (10.0%)
Informal Learning	0 (0.0%)	0 (0.0%)

Note: ***Top one topic, **top two topic, *top three topic.

Curriculum (15%), and Teacher Education (15%). The results also confirmed the aforementioned viewpoint that science educators have shifted their research foci during the 10 years. In addition, the top three topics of highly-cited papers in 1998–2002 (i.e., Learning—Context; Goals, Policy, and Curriculum; and Philosophy, History, and Nature of Science), except Learning—Context, were different from the top three topics of published papers in 2003–2007 (i.e., Learning—Contexts, Learning—Conceptions, and Teaching). The topics of Goals, Policy, and Curriculum and of Philosophy, History and Nature of Science are probably the foundation of Learning—Contexts, Learning—Conceptions and Teaching. For example, the research about student learning and science teaching should be based on the goals, curriculum, and some of the philosophical perspectives of the nature of science. It is plausible to find that some highly-cited papers in the topics of 1998–2002 may induce more research in student learning and science teaching in 2003–2007.

In addition, a cross-analysis regarding the research type and topic of highly-cited articles in 1998–2007 was conducted, indicating that the research topic regarding Goals, Policy, and Curriculum published relatively more 'position' and 'theory' papers than other research topics. It seems to reveal that some papers without empirical research in this topic are highly recognised by science educators in 1998–2007.

Moreover, it can also be seen in the Appendix that most of the top 10 highly-cited papers in 1998–2002 were concerned with either the 'nature of science' (i.e., the studies numbered fourth, fifth, and eighth) or 'argumentation' (i.e., the studies numbered first, second, ninth, and tenth). In addition, most of the top 10 highly-cited papers in 2002–2007 were concerned with 'argumentation (including informal reasoning)' (the papers numbered second, third, and fifth were concerned with argumentation, and the papers numbered seventh and tenth were concerned with informal reasoning) or 'scientific literacy' (i.e., the papers numbered first and ninth). It seems that the research topic of 'argumentation' was highlighted by science educators in 1998–2007. In particular, in the research area of argumentation, issues regarding informal reasoning have received increasing attention from researchers in 2003–2007. Scientific literacy has become another important issue highlighted by science educators in 2003–2007.

Summary and Conclusion

Through a series of content analyses of articles published in IJSE, SE, and JRST during 2003–2007, and by comparing the results of the present study with Tsai and Wen's (2005) research, this study made various findings regarding the research trends of the past decade. We summarise the major findings as follows.

Although researchers from four English-speaking countries—the USA, the UK, Australia, and Canada—on the whole, published a major proportion of the articles (i.e., 62.5%) in the three journals during these five years (Table 10), authors from other countries also played an important role. Compared with Tsai and Wen's (2005) findings, authors from other countries contributed to the journals more in

2003–2007 (i.e., 37.5%) than they did in 1998–2002 (i.e., 28.3%). This implies that the research community in science education has progressively internationalised, and more and more researchers from different counties can share their research findings with the community. As acknowledged by Treagust (2000) in his presidential address to the members of National Association for Research in Science Teaching, science education is a growing international research domain and the numbers of non-American members are greatly increasing. From his perspective, the results of this study may be particularly beneficial to science education researchers from other countries that are not listed in this study in enhancing their understanding of contemporary research trends in science education as well as motivating their possible contributions to this field in the future.

During these five years (2003–2007), science educators showed most interest in research topics regarding student learning contexts, such as learning environment, reasoning, and the affective dimensions of science learning. However, researchers may have changed some of their research topics within the 10 years. They showed increasing interest in research topics regarding student learning contexts and teaching, while student conceptions and conceptual change, as well as culture, social, and gender issues, received declining attention.

The reason for the declining trend of student conceptions and conceptual change observed in this study may relate to the mature development of this topic as a result of the many efforts in the field of science education in the past (e.g., Scoot, Asoko, & Leach, 2007). The steps required to improve student conception learning and conceptual change, and/or to resolve further issues arising from the research into conception learning and conceptual change, may consider the students' learning context. Thus, researchers have shifted their focus to the student learning context. Moreover, the research topic of 'Teaching' may be an important way to improve and resolve the issues arising from conception learning and conceptual change research, and thus gained the third ranking in 2003–2007 (Table 12).

In this study, highly-cited papers published in the three journals during 1998–2002 and 2003–2007 were also identified. It was found that although most of the highly-cited papers in 1998–2002 as well as in 2003–2007 were empirical studies, the position paper, theoretical paper, and review also played an important role. Besides, among these empirical studies, most of them were qualitative studies while the others were all mixed-method studies. It is interesting to find that none of them was conducted by a solely quantitative method. Moreover, from the topics of the highly-cited papers in 1998–2002 and 2003–2007, most of the top 10 highly-cited papers in 1998–2002 were concerned with either the 'nature of science' or 'argumentation', while most of the top 10 highly-cited papers in 2002–2007 were concerned with 'argumentation (including informal reasoning)' or 'scientific literacy'. It seems that the topic of argumentation has received significant attention from science researchers in the past decade. Nowadays, one important goal of science education is the preparation for future citizenship with the aim of enhancing students' ability to solve the problems arising from real life. Argumentation plays an important role in solving real-life problems. Thus, researchers have highlighted the

importance of argumentation in science education and have shifted their attention from scientific conception learning to the issues of argumentation. It should be noted that, in the research area of argumentation, studies regarding informal reasoning have been highlighted during 2003–2007, and these studies may show its lasting and increasing impact on further research in the next five years. Besides, further research regarding scientific literacy may also be gradually highlighted by science educators in the future.

The findings of this study also concur with those proposed by Abell and Lederman (2007) in their handbook on science education for the advancement of research in science education. For example, according to the analysis of highly-cited articles in this study, research topic regarding argumentation (including informal reasoning) has received significant attention from researchers in science education, and argumentation plays an important role in solving real-life problems for science students. Similarly, Abell and Lederman (2007) have advocated that the connections between research and real life should be highlighted. Moreover, Abell and Lederman (2007) have also suggested the use of a mixed research method. In this study, the gradual acceptance of a mixed research method among highly-cited papers in science education in the last decade was revealed.

As a follow-up to Tsai and Wen's (2005) research, this study analysed the articles published in IJSE, SE, and JRST in 2003–2007. The research trends about topics, methods, as well as the most highlighted issues revealed in this study, to some extent, illustrated the development of research in the field of science education in the past decade, and may also suggest some possible directions for the development of further research in this field. It is hoped that this study will be beneficial for researchers and educators in science education in conducting their research, and in publishing their research findings. This study can also provide policy-makers and practitioners in science education with information regarding which issues were extensively studied in the field of science education, and the information may serve as one of the important bases in improving the quality of their policy-making decisions and instructional practice. In particular, this study is expected to provide younger scholars with a complete and clearer picture of the research conducted in the community of science education, as well as to broaden their scope of research and their publication contributions. For example, the analyses in this study may help younger scholars not only to identify research topics, methods, and trends in this field, but also to recognise the research issues contemporarily highlighted.

This study also aims to provide an opportunity for researchers in science education to reconsider the next step of research in the field. Undoubtedly, as a growing international research domain, some possible challenges to research in science education may occur in the future. For example, more and more researchers from different cultures and various social contexts (in particular, from non-English-speaking countries) contribute to the field of science education. How to integrate their findings derived from different socio-cultural variations and apply these findings in global science education is one of the most difficult challenges for researchers in the community. Perhaps more cross-national or cross-cultural studies will be

helpful. The cooperation of researchers from different socio-cultural contexts will be one of the important issues for the advancement of this field.

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Appendix. Top 10 highly-cited papers (by citation counts per year, as at February 29, 2008) in 1998–2002 and 2003–2007

1998–2002	*Title*	*Journal (year), page.*
1	Establishing the norms of scientific argumentation in classrooms	*SE* (2000), 287–312.
2	Fostering students' knowledge and argumentation skills through dilemmas in human genetics	*JRST* (2002), 35–62.
3	Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks	*SE* (2002), 175–218.
4	Improving science teachers' conceptions of nature of science: a critical review of the literature	*IJSE* (2000), 665–701.
5	The nature of science and instructional practice: Making the unnatural natural	*SE* (1998), 417–436.
6	Articulating communities: Sociocultural perspectives on science education	*JRST* (2001), 296–316.
7	The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective	*SE* (2000), 740–756.
8	Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science	*JRST* (2002), 497–521.
9	Scientific arguments as learning artifacts: designing for learning from the web with KIE	*IJSE* (2000), 797–817.
10	The place of argumentation in the pedagogy of school science	*IJSE* (1999), 553–576.

2003–2007	*Title*	*Journal (Year), page.*
1	How literacy in its fundamental sense is central to scientific literacy	*SE* (2003), 224–240.
2	Enhancing the quality of argumentation in school science	*JRST* (2004), 994–1020.
3	Learning to teach argumentation: Research and development in the science classroom	*IJSE* (2006), 235–260.
4	Conceptual change: a powerful framework for improving science teaching and learning	*IJSE* (2003), 671–688.
5	TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse	*SE* (2004), 915–933.
6	Attitudes towards science: a review of the literature and its implications	*IJSE* (2003), 1049–1079.
7	Informal reasoning regarding socioscientific issues: A critical review of research	*JRST* (2004), 513–536.
8	The laboratory in science education: Foundations for the twenty-first century	*SE* (2004), 28–54.
9	Examining the literacy component of science literacy: 25 years of language arts and science research	*IJSE* (2003), 689–725.
10	Patterns of informal reasoning in the context of socioscientific decision making	*JRST* (2005), 112–138.