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Research and trends in science education from 1998 to 2002: a content analysis of publication in selected journals

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RESEARCH REPORT

Research and trends in science education from 1998 to 2002: a content analysis of publication in selected journals

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This study conducted a series of content analyses of the articles published by *International Journal of Science Education*, *Science Education*, and *Journal of Research in Science Teaching* from 1998 to 2002. A total of 802 research papers were analyzed in terms of the authors' nationality, research types and topics. It was found that researchers in four major English-speaking countries, including the US, the UK, Australia, and Canada, contributed to a majority of the publications, but the researchers from other non-English countries may have, to a certain extent, gradually played a valuable role on the published work. This probably implies that science education research may have progressively become an important field recognized by the international academic community. This study also found that most of the published articles were categorized as empirical studies, while position, theoretical and review papers were rarely presented in the journals. Although the research topic of students' conceptions and conceptual change was the most frequently investigated one in these five years, a declining trend was observed when analyzed by year. Moreover, in 1998–2002, the research topics related to student learning contexts, and social, cultural and gender issues were also received relatively more attention among science educators.

Introduction

'Writing for publication' is always one of the major tasks for researchers. Through publications, the research findings can, on the one hand, be widely recognized in the academic community, and, on the other hand, the researchers can advance their own careers for applying tenure, promotion, grants or scholar awards (Henson 1997, 1999, 2001). Similarly, science education researchers often view the publications of research findings in academic or refereed journals as an important task for their profession. For new researchers, being aware of some important academic journals helps them to understand the field of science education more broadly. Therefore, having a systematic analysis of articles published in academic journals may assist science educators to explore the current status and future trends of research.

In the field of psychology and educational psychology, some researchers have conducted several content analyses for certain journals (e.g. APA journals). However, many of these analyses were designed for the evaluation of institutional productivity (for example, Howard 1983, Howard et al. 1985, 1987), or that of individual researchers in psychology (for example, Smith et al. 1998). In recent years, within the field of science education, there are probably only two research reports

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that have given a systematic examination of the research papers published in academic journals (Eybe and Schmidt 2001, Rennie 1998). Rennie (1998) surveyed research articles of five English-language science education journals published in 1996 to illustrate the quality of quantitative research articles. Rennie made several recommendations as how to improve the research quality of related papers, including the use of correct terminology, the provision of sufficient information about the data to enable replications to be made, and the reporting and interpretation of effect magnitudes. Eybe and Schmidt (2001) examined research papers in chemistry education specifically based upon the quality criteria of publication from academic journals, reports, and documents. These researchers selected 81 chemical education studies from 1991 to 1997 published in the *International Journal of Science Education* (IJSE) and the *Journal of Research in Science Teaching* (JRST). These studies were reviewed according to six quality categories and corresponding criteria: (1) theory-relatedness, (2) quality of the research question, (3) methods, (4) presentation and interpretation of results, (5) implications for practice, and (6) competence in chemistry. These reports have given specific guidance for science education researchers on how to conduct research and to publish quality articles. However, a more comprehensive content analysis of professional publications may be helpful in revealing the recent trends of science education research in general.

In the field of science education, an increasing number of research projects have been undertaken cooperatively and internationally by incorporating multiple perspectives from all kinds of cultures (for example, Cardoso and Solomon 2002, She and Fisher 2000, Tiberghien et al. 2001, Wallace and Chou 2001). Researchers with a variety of cultural backgrounds have gradually begun to contribute their ideas to the field (Jenkins 2000). Therefore, a thorough examination of the nationality of authors who contribute to academic research will provide more information for the growing international aspect of science education research. Furthermore, as asserted by Jenkins (2000), the field of science education currently entails substantial and notable diversity. In addition to the variations of nationality of researchers involved, the diversity may include the variations of the methodologies used and the research topics chosen for exploration. A careful analysis of the research types and topics currently published by major journals may be beneficial to contemporary science educators by enabling them to examine research trends. It is therefore proposed to fully analyze the academic papers published by major journals in terms of the variations (and contribution) of authors' nationality, research types and topics.

This study analyzed publications from three major science education journals within the most recent five years (1998–2002). The three selected journals were IJSE, JRST, and *Science Education* (SE). These three journals have been the science education journals included in the Social Sciences Citation Index for quite a long time, and they had high and similar impact factors as released by the Institute for Scientific Information *Journal Citation Reports*. Take the impact factor ranks of 2001, for example, SE was top 15th among more than 90 educational journals, and JRST and IJSE were the 23rd and 38th, respectively. These three journals are also highly recognized and widely accessed academic science education journals worldwide. Consequently, the questions addressed by this paper are:

1. How did authors from different countries contribute to the publications of these selected journals from 1998 to 2002?

2. How did the types of research published in the journals vary across these five years?
3. How did the research topics published in the journals vary across these five years?

Method

Research papers for analysis

This study used all of the papers published in IJSE, JRST, and SE from 1998 to 2002 (five years) as the research sample to examine the research and trends in science education. However, the papers of the types of 'editorial', 'commentary', 'responses' and 'book reviews' have been excluded from the analysis. A total of 802 articles were analyzed.

Authors' nationality

The research contribution by each country was analyzed quantitatively and ranked for these three journals within five years. Each paper was given one point. If a paper was published by more than one author who came from different countries, the one point was divided into certain proportions for each participating country. In this case, the score of a specific author in a multi-author paper was calculated by a formula from Howard et al. (1987):

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

where n is the total number of authors in this paper, and i is the order of the specific author.

A detailed score allocation derived from this formula is presented in table 1. For instance, if a paper was written by two authors, and the first one was a UK author while the second one was a US author, then for this particular paper the UK will get a score of 0.6 while the USA will acquire a score of 0.4. By this method, the accumulated score for each country was calculated and compared by year and by journal.

Table 1. Author's score allocation for multi-author research papers.

	Order of specific author				
Number of authors	1	2	3	4	5
1	1				
2	0.60	0.40			
3	0.47	0.32	0.21		
4	0.42	0.28	0.18	0.12	
5	0.38	0.26	0.17	0.11	0.08

Note: The value in each cell indicates a specific author's score in a multi-author paper when a paper is counted as one point.

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Research type

The research type of each published article was classified into one of the following five categories: (1) empirical research article, such as quantitative and qualitative research; (2) position paper, which held a specific position in a certain issue of science education; (3) theoretical paper, which proposed a new theory or theoretical framework in the field of science education; (4) review, which summarized research literatures without proposing a strong position; and (5) other (e.g. a description of science curricula of a specific country). These categories were similar to those used by Smith et al. (1998) in the field of educational psychology. The papers were categorized by two researchers (both holding a doctoral degree in science education) with an agreement of 0.96. The different opinions were further discussed between them and categorized on agreement. The frequencies of each category were calculated for analysis.

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Research topic

In this study, the researchers categorized the research topic of each published article into one of the following nine categories: (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 criteria for each category were mainly adapted from the National Association for the Research in Science Teaching conference strand categories (http://www.educ.sfu.ca/narst/sub-g-proc.html#47858). The revised categories with some typical topics are now listed.

1. *Teacher Education*. Preservice and continuing professional development of teachers; teacher education programs and policy; field experience; issues related to teacher education reform; teacher as researcher/action research.
2. *Teaching*. Teacher cognition; pedagogical knowledge and pedagogical content knowledge; forms of knowledge representation (e.g. metaphors, images, etc.); leadership; induction; exemplary teachers; teacher thinking; teaching behaviors 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 (Leaning — 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; research methods.
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 same two science educators classified each research paper into one (and only one) *best-fit* category among these nine categories. The categorization process resulted in an agreement of 0.86. Again, disagreements were solved by discussion. The frequencies of each topic category were calculated for analysis.

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Results

Published papers by authors' nationality

An analysis about the variation of the authors' nationality revealed the following findings. During the years 1998–2002, authors from 21 countries contributed to the publications of JRST. SE included the authors from 23 countries, while IJSE had the authors from 36 different countries. To analyze the research contribution by country, each paper was granted one point and a paper with multi-authors coming from different countries was scored as presented in table 1 or by the formula proposed by Howard et al. (1987). Consequently, the country scores were analyzed by year (table 2) and by journal (table 3). When analyzed by year, the USA, the UK, and Australia were consistently the top three countries of higher scores from 1998 to 2002 (table 2). For IJSE, authors from the UK, the USA, and Australia had the most publications. For JRST, authors from the USA, Canada, and Australia published most. For SE, most authors came from the USA, Australia, and Canada (table 3).

That English-speaking countries contributed most to these three journals is perhaps due to the language used. To further examine the publication of non-English speaking countries, the nationality of authors was categorized into five groups: the USA, the UK, Australia, Canada, and the other (many of them are non-English speaking) countries (Tables4 and 5). These four English-speaking countries contributed a major proportion of academic publications. For example, from 1998 to 2002, these four countries contributed to approximately 67–75% of publications by these journals (table 4). The research papers from these four countries made up over 86% in JRST, and over one-half in IJSE and SE (Table 5).

A chi-square test on the cells of table 4 showed no significant differences in publications of each country group over the five years (chi-square = 11.48, degrees of freedom = 16, not significant). However, the chi-square test on table 5 revealed that there were differences in country group contribution among the three journals (chi-square = 77.62, degrees of freedom = 8, $p < 0.001$). For instance, other countries (mostly non-English speaking) — other than the USA, the UK, Australia and Canada — contributed to about 40% of published articles in IJSE, about 27% in SE,

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Table 2. Country ranks of publication from 1998 to 2002 (top 10).

	1998–2002		*1998*		*1999*		*2000*		*2001*		*2002*	
Rank	*Country*	*Score*	*Country*	*Score*	*Country*	*Score*	*Country*	*Score*	*Country*	*Score*	*Country*	*Score*
1	USA	346.35	USA	62.85	USA	63.82	USA	69.98	USA	78.39	USA	71.34
2	UK	121.76	UK	31.35	UK	27.89	UK	24.99	UK	22.33	UK	15.20
3	Australia	69.18	Australia	12.32	Australia	21.04	Australia	13.00	Australia	10.00	Australia	12.82
4	Canada	37.48	Canada	12.15	Spain	8.53	Canada	6.00	Canada	7.27	Taiwan	8.60
5	Israel	29.75	Israel	8.00	Israel	8.00	Israel	4.73	Norway	5.00	Netherlands	6.00
6	Spain	24.20	Germany	6.00	Canada	7.82	Spain	4.67	Israel	4.74	Spain	5.00
7	Taiwan	20.80	Netherlands	5.00	Taiwan	5.20	SouthAfrica	3.94	China	4.60	Israel	4.28
8	Netherlands	15.47	Greece	4.00	Greece	4.40	Taiwan	3.60	SouthAfrica	3.87	Canada	4.24
9	SouthAfrica	14.68	SouthAfrica	3.02	Brazil	2.79	Brazil	3.00	Spain	3.00	Sweden	4.00
10	Germany	12.08	Spain	3.00	SouthAfrica	2.64	Germany	2.28	Netherlands	2.00	France	3.00
									Singapore	2.00		

Table 3. Country ranks and percentages of publication in individual journals (top 10).

	SE		*JRST*		*IJSE*	
Rank	*Country*	*Score (%)*	*Country*	*Score (%)*	*Country*	*Score (%)*
1	USA	99.18 (55.1%)	USA	183.50 (70.8%)	UK	103.61 (28.5%)
2	Australia	14.56 (8.0%)	Canada	14.24 (5.5%)	USA	63.67 (17.5%)
3	Canada	10.87 (6.0%)	Australia	13.90 (5.4%)	Australia	40.72 (11.2%)
4	Spain	7.58 (4.2%)	UK	11.66 (4.5%)	Israel	18.68 (5.1%)
5	UK	6.49 (3.6%)	Israel	5.60 (2.2%)	Spain	12.79 (3.5%)
6	Taiwan	5.60 (3.1%)	Netherlands	4.45 (1.7%)	Taiwan	12.60 (3.5%)
7	Israel	5.47 (3.0%)	Spain	3.83 (1.5%)	Canada	12.37 (3.4%)
8	Greece	4.00 (2.2%)	South Africa	2.67 (1.0%)	Netherlands	9.00 (2.5%)
9	South Africa	3.12 (1.7%)	Taiwan	2.60 (1.0%)	South Africa	8.89 (2.4%)
10	Singapore	2.64 (1.5%)	Singapore	2.60 (1.0%)	China	8.80 (2.4%)

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and only 13.8% in JRST. US authors presented more than 70% of articles in JRST, 55% in SE, and only 17.7% in IJSE. IJSE published more authors from diverse non-English-speaking countries.

Published papers by research type

Table 6 illustrates the trends of research types from 1998 to 2002. Within these five years, the empirical study was the major type of publication, ranging from 83.6% to 90.9%.

An analysis of research type by journal is presented in table 7. For all these three journals, most published articles were empirical studies, followed by position papers, with only a few theoretical papers, reviews of literature, and other types of articles.

Published papers by research topics

The published papers were analyzed by research topics, and the five-year results are presented in table 8. The top two topics in each year are highlighted.

As an extension of the research work initiated by Novak (for example, Helm and Novak 1983, Novak 1977) and Driver (for example, Driver and Easley 1978, Driver and Erickson 1983) on student alternative conceptions in the 1980s, the category 'Learning — Conception' consistently ranked in the top two topics from 1998 to 2002, with an average of 24.7% of the total research articles. Despite its popularity with science educators, however, this category had a declining trend within these years, decreased from 33.3% in 1998 to 20.8% in 2002 (table 8). Science educators also showed interests in 'Learning — Context' topics, such as cooperative learning, affective domains, and interactions within learning environments, with an average of 17.9% articles classified in this category during these five years. Furthermore, issues about 'Culture, Social, and Gender' have also attracted attention by science educators. Surprisingly, the papers about the research issues of 'Teacher Education',

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Table 4. Country ranks and percentages of publication from 1998 to 2002 (top five groups).

1998		*1999*		*2000*		*2001*		*2002*	
Country	*Score (%)*	*Country*	*Score (%)*	*Country*	*Score (%)*	*Country*	*Score (%)*	*Country*	*Score (%)*
USA	62.85 (38.1%)	USA	63.82 (37.3%)	USA	69.98 (44.8%)	USA	78.39 (50.2%)	USA	71.34 (46.3%)
UK	31.35 (19.0%)	UK	27.89 (16.3%)	UK	24.99 (16.0%)	UK	22.33 (14.3%)	UK	15.20 (9.9%)
Australia	12.32 (7.5%)	Australia	21.04 (12.3%)	Australia	13.00 (8.3%)	Australia	10.00 (6.4%)	Australia	12.82 (8.3%)
Canada	12.15 (7.4%)	Canada	7.82 (4.6%)	Canada	6.00 (4.0%)	Canada	7.27 (4.7%)	Canada	4.24 (2.8%)
Others	46.33 (28%)	Others	50.43 (29.5%)	Others	42.03 (26.9%)	Others	38.01 (24.4%)	Others	50.40 (32.7%)

Note: Chi-square = 11.48, degrees of freedom = 16, $p = 0.779$.

Table 5. Country ranks and percentages of publication in individual journals (top five groups).

SE		*JRST*		*IJSE*	
Country	*Score (%)*	*Country*	*Score (%)*	*Country*	*Score (%)*
USA	99.18 (55.1%)	USA	183.50 (70.8%)	USA	63.67 (17.7%)
UK	6.49 (3.6%)	UK	11.66 (4.5%)	UK	103.61 (28.5%)
Australia	14.56 (8.0%)	Australia	13.90 (5.4%)	Australia	40.72 (11.2%)
Canada	10.87 (6.0%)	Canada	14.24 (5.5%)	Canada	12.37 (3.4%)
Others	48.9 (27.3%)	Others	34.7 (13.8%)	Others	143.63 (39.2%)

Note: Chi-square = 77.62, degrees of freedom = 8, $p < 0.001$.

Table 6. Frequencies and percentages of research types from 1998 to 2002 (n = 802 papers).

Research type	*1998–2002*	*1998*	*1999*	*2000*	*2001*	*2002*
Empirical	697 (86.9%)	138 (83.6%)	149 (87.1%)	139 (89.1%)	131 (84.0%)	140 (90.9%)
Position	75 (9.4%)	19 (11.5%)	15 (8.8%)	10 (6.4%)	20 (12.8%)	11 (7.1%)
Theory	6 (0.7%)	3 (1.8%)	1 (0.6%)	2 (1.3%)	0	0
Review	13 (1.6%)	4 (2.4%)	1 (0.6%)	3 (1.9%)	3 (1.9%)	2 (1.3%)
Other	11 (1.4%)	1 (0.6%)	5 (2.9%)	2 (1.3%)	2 (1.3%)	1 (0.7%)

Table 7. Frequencies and percentages of research types in individual journals (n = 802 papers).

Research type	*SE*	*JRST*	*IJSE*
Empirical	151 (83.9%)	229 (88.8%)	317 (87.1%)
Position	23 (12.8%)	21 (8.1%)	31 (8.6%)
Theory	0	2 (0.8%)	4 (1.1%)
Review	2 (1.1%)	5 (1.9%)	6 (1.6%)
Other	4 (2.2%)	1 (0.4%)	6 (1.6%)

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'Teaching', and 'Educational Technology' did not contribute much to the total quantity of published articles.

In addition to the analysis by year, the research topics were examined by journal, presented in table 9. Table 9 reveals that the first and second ranks of topics for IJSE and SE were 'Learning — Conception' and 'Learning — Context'. The category 'Learning — Conception', with the aforementioned popularity, comprised one-third (33.0 %) of research articles in IJSE. For JRST specifically, 'Culture, Social, and Gender' and 'Learning — Context' were the top two research topics published in the journal. Among these three journals, this analysis of publication topics showed similarities in emphasis on learning and differences in other highlighted areas. The journal scope, editorial policies and the identities of the Editors might play a role in

Table 8. Frequencies and percentages of research topics from 1998 to 2002 (n = 802 papers).

Research topic	*1998–2002*	*1998*	*1999*	*2000*	*2001*	*2002*
Teacher Education	56 (7.0%)	13 (7.9%)	12 (7.0%)	12 (7.7%)	11 (7.1%)	8 (5.2%)
Teaching	55 (6.9%)	8 (4.8%)	11 (6.4%)	10 (6.4%)	8 (5.1%)	18 (11.7%)
Learning — Conception	198 (24.7%)*	55 (33.3%)*	40 (23.4%)*	41 (26.3%)*	30 (19.2%)*	32 (20.8%)*
Learning — Contexts	144 (17.9%)*	21 (12.8%)	34 (19.9%)*	28 (17.9%)*	29 (18.6%)	32 (20.8%)*
Goals, Policy, Curriculum	109 (13.6%)	22 (13.3%)	20 (11.7%)	17 (10.9%)	25 (16.0%)	25 (16.2%)
Culture, Social and Gender	115 (14.3%)	27 (16.4%)*	27 (15.8%)	15 (9.6%)	31 (19.9%)*	15 (9.7%)
Philosophy and History	68 (8.5%)	11 (6.7%)	14 (8.2%)	17 (10.9%)	12 (7.7%)	14 (9.1%)
Educational Technology	27 (3.4%)	5 (3.0%)	5 (2.9%)	11 (7.1%)	3 (1.9%)	3 (1.9%)
Informal Learning	30 (3.7%)	3 (1.8%)	8 (4.7%)	5 (3.2%)	7 (4.5%)	7 (4.6%)

*Top two topics.

Table 9. Frequencies and percentages of research topics in individual journals (n = 802 papers).

Research topic	*SE*	*JRST*	*IJSE*
Teacher Education	15 (8.3%)	19 (7.4%)	22 (6.0%)
Teaching	18 (10.0%)	24 (9.3%)	13 (3.6%)
Learning — Conception	37 (20.6%)*	41 (15.9%)	120 (33.0%)*
Learning — Contexts	30 (16.7%)*	50 (19.4%)*	64 (17.6%)*
Goals, Policy, Curriculum	28 (15.6%)	29 (11.2%)	52 (14.3%)
Culture, Social and Gender	24 (13.3%)	59 (22.9%)*	32 (8.8%)
Philosophy and History	18 (10.0%)	27 (10.5%)	23 (6.3%)
Educational Technology	2 (1.1%)	8 (3.1%)	17 (4.7%)
Informal Learning	8 (4.4%)	1 (0.4%)	21 (5.7%)

the publication topics. For future studies, it is also worth asking the journal Editors for their comments on the results.

Discussion and conclusion

This study conducted a series of content analyses of publications in three science education journals from 1998 to 2002. Although researchers in some major English-speaking countries (i.e. the US, the UK, Australia, and Canada) contributed to a major part of the publications, the researchers from other non-English countries may have, to a certain extent, also played an important role on this. For example, according to table 4, in the year of 2002, about one-third of the publications by these journals came from the authors other than the four major English-speaking countries (32.7%). Research in science education may have progressively become an important field among the international research community. Some cross-nation comparative studies for student science achievement and attitude have involved a

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growing number of participating countries; for example, the Trends in International Mathematics and Science Study (TIMSS) 1999 included 38 countries for investigation (Martin etal. 2000), and TIMSS 2003 would include around 50 countries (TIMSS 2003).

This study revealed that most of the published articles were categorized as empirical studies, while position, theoretical and review papers were rarely presented in the journals. The research topic of students' conceptions and conceptual change was the most frequently investigated one in these five years, but this topic probably showed a declining trend when analyzed by year. In recent years, research topics related to student learning contexts, and social, cultural and gender issues also received relatively more attention.

The content analyses conducted in this study were valuable and different from relevant studies presented previously. First, this study analyzed the publications in terms of authors' nationality, while previously research work may have emphasized the individual, departmental and institutional productivity (refer to the review by Toutkoushian et al. 2003). The nationality analysis may more reflect the growing international feature of research community. In addition, this study also analyzed the research types and topics, helping researchers explore the current status of research and trends in the field.

It is hoped that the analysis will provide some guidance for science educators, particularly new researchers, in making appropriate decisions and broadening their scopes when conducting research and writing academic publications in the future. It is also recommended that a similar study be repeated in every five years; science education researchers can then monitor and review the research trends, and possibly find more international contribution to the field and some shifts of research trend.

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