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An Academic Trend on Undergraduate Research in Higher Education Based on Bibliometric and Co-word Analysis

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Abstract: Based on the database of ISI Web of knowledge, this study utilized the bibliometric and co-word method to depict literature characteristics of undergraduate research, including distribution of year and journals, publication countries, subject area, and research themes. Results show that the undergraduate research experiences an overall trend of rapid development with an imbalance in the number and impact of regional documents. The importance, curriculum design and experience research denote the current direction, and the upper-division undergraduates and inquiry-based/discovery learning will become the central issues in the future.

Keywords: Undergraduate Research, Bibliometric Analysis, Co-word Analysis, Research Theme

1. Introduction

The development of economy and innovation of education is mutual promotion. Since education reform centered on education innovation in 1970s in Europe and the United States, education innovation which focused on thinking innovation and ability innovation played a significant role in promoting economic development. At present, faced with the goal of building an innovation oriented country which needs to cultivate a large number of innovation talents, university education can also provide a unique environment, and the physical and mental characteristics of college students determine that the undergraduate stage is the critical stage of talent growth. However, for a long time, undergraduate education places too much emphasis on imparting knowledge, neglecting the cultivation of ability, and more on the basis of teachers, neglecting students' initiative and thus often stifling the creativity of students. So we should focus on undergraduate education again, and further focus on undergraduate research.

Research activities are considered as one of the most influential teaching practices. Undergraduate research is a very important part in the teaching practice of higher education [1]. Undergraduate research has been developed rapidly in European and American countries by making undergraduates participate in scientific research activities to cultivate their practical ability and comprehensive quality. Since the 1990s, Tsinghua University has been introduced undergraduate research to China, then the Ministry of Education in China also launched a formal program of undergraduate research projects, which makes more and more universities to carry out a wide range of research activities for undergraduates. So it is therefore necessary to analyze the changes in this field.

2. Literature Review

Now the undergraduate research has enjoyed widespread popularity from scholars and they have achieved certain research results. A review of the relevant literature reveals that previous studies can be grouped into three research streams.

Some scholars paid attention to the theoretical foundation. Several frameworks have been developed to comprehend undergraduate research with its various facets. Stößlein et al. (2008) suggest differentiating the undergraduate research activities into five phases: Planning, Coaching, Documenting,

Evaluating and Disseminating [2]. Healey et al. (2010) classifies undergraduate research into the scope of the research tasks and situates students [3]. Levy et al. (2012) distinguish four types of undergraduate research: "identifying, pursuing, producing, or authoring" [4]. Linn, et al (2015) also analyze the impacts and opportunities of undergraduate research [5].

The inventory of quantitative research regarding pedagogical benefits of undergraduate research is considerable, in particular with focus on instilling higher level thinking skills [6], enhancing student knowledge [7], science literacy [8] and developing problem solving skills [9].

In addition, empirical evidence of key success factors for undergraduate research is hardly presented. Webber, et al, (2013) research how the factors influence student participation in undergraduate research, like faculty involvement, student success [10]. Eagan, et al, (2011) investigated the factors that affect faculty members' decisions to allow undergraduates to their research projects [11].

In summary, the current scholars provide a lot of valuable references for undergraduate research, which provides a good foundation for follow-up research, but no systematic analysis has yet to be carried out of the large body of research in this area. This article aims to assess the development and growth of research in this field by reviewing the related scientific literature.

3. Methodology

3.1. Research Method

The main bibliometric analysis were applied to study scientific growth over time, the dispersion of scientific output across journals, country productivity and research area.

Co-word analysis draws upon the assumption that a paper's keywords can give an adequate description of content. In this study, we depict the keywords network of research, in which the nodes are the keywords while the links represent the co-occurrence of these keywords. VOSviewer is a software tool for constructing and visualizing bibliometric maps. Unlike most computer programs that are used for bibliometric mapping, VOSviewer is especially useful for displaying large bibliometric maps in an easy-to-interpret way, and pay more attention to drawing and clustering [12]. So we hope to use it to make a clearer and richer keyword co-occurrence analysis of undergraduate research.

3.2. Date Collection

To retrieve sufficient "undergraduate research' related papers, the Web of Science literature database is initially used for paper retrieval. In order to have sufficient coverage of the papers and avoid too much useless data and avoid adverse effects on the research results, the following query has been searched in the topic: "undergraduate research" or "undergraduates research". The data were extracted in January 2018, with the search in the topic field covering the period from 2000 to 2017. Finally, a total of 757 articles were retrieved and selected as the analysis sample.

4. Results of Bibliometrics Analysis

4.1. Number of Papers

After analyzing the literature collection of undergraduate research from the WOS database, the publication growth of undergraduate research from 2000 to 2017 was shown in Figure 1. The academic trend of undergraduate research increased rapidly from 2000, which indicate that undergraduate research has gradually become the focus in the field of educational research, and this trend is constantly strengthening.

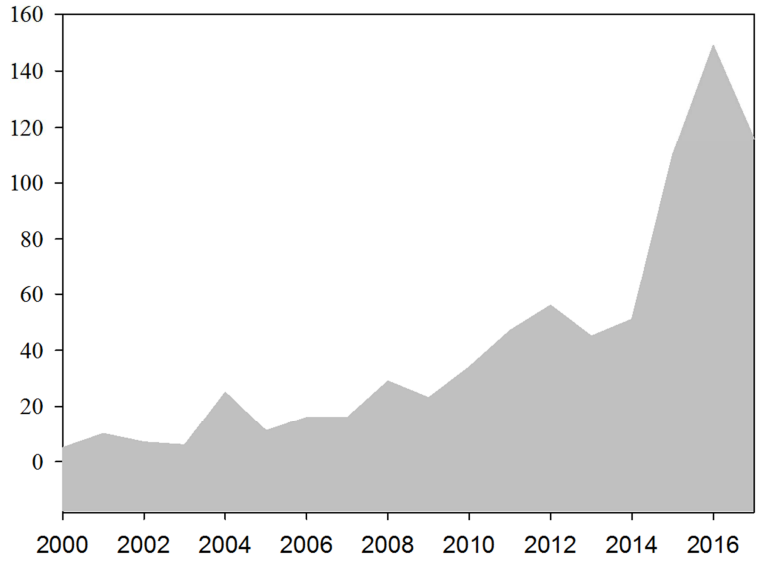

Figure 1. *The academic trend of undergraduate research literature over time (2000-2017).*

4.2. Top Journals

We ranked journals on their total contribution to the list of articles. The top 12 journals with the largest number of

publications were identified. The result is presented in Figure 2. In addition to 2 comprehensive journals, most of them belong to the area of Education and Educational Research.

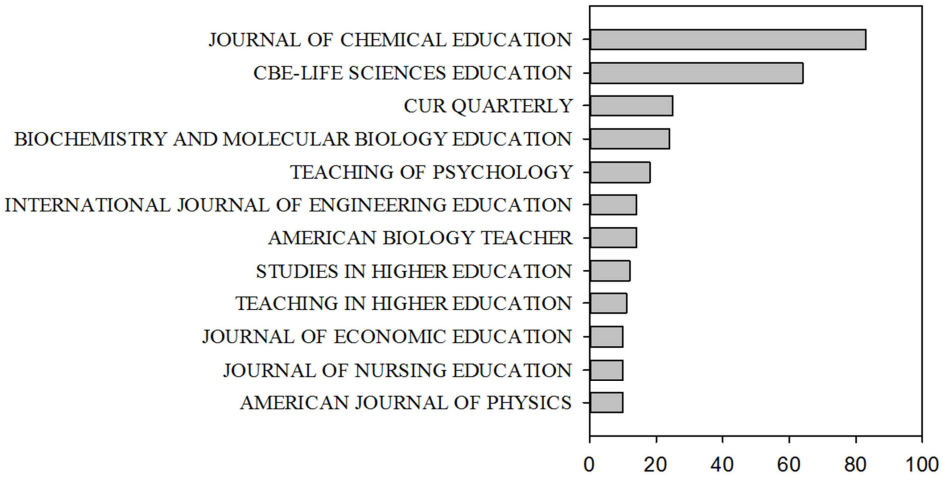

Figure 2. *Leading journals contributors in undergraduate research.*

4.3. Country Distribution

Table 1 lists country distribution of undergraduate research literature. USA is far ahead, publishing around 73.448% of undergraduate research literature. Australia (6.473%) and England (5.812%) contributed the second and third position, and Canada, Brazil, Saudi Arabia and New Zealand each of them contributed more than 1.0% among the total literature.

Table 1. *Top 15 counties or territories in undergraduate research.*

Country	Count	Percent	Country	Count	Percent
USA	556	73.448%	China	7	0.925%
Australia	49	6.473%	Scotland	7	0.925%
England	44	5.812%	Germany	6	0.793%
Canada	21	2.774%	Portugal	6	0.793%
Brazil	20	2.642%	South Africa	6	0.793%
Saudi Arabia	10	1.321%	Spain	5	0.661%
New Zealand	8	1.057%	Sweden	5	0.661%

4.4. Subject Area

Figure 3 lists the most concerned subject area of undergraduate research literature. The top 5 concerned area of undergraduate research literature included "Education & Educational research", "Chemistry", "Psychology", "Engineering" and "Information Science & Library Science". The major area of undergraduate research literature was "Education & Educational research" for sure. However, the result also indicated that undergraduate research has been considered as an important issue in multidisciplinary field.

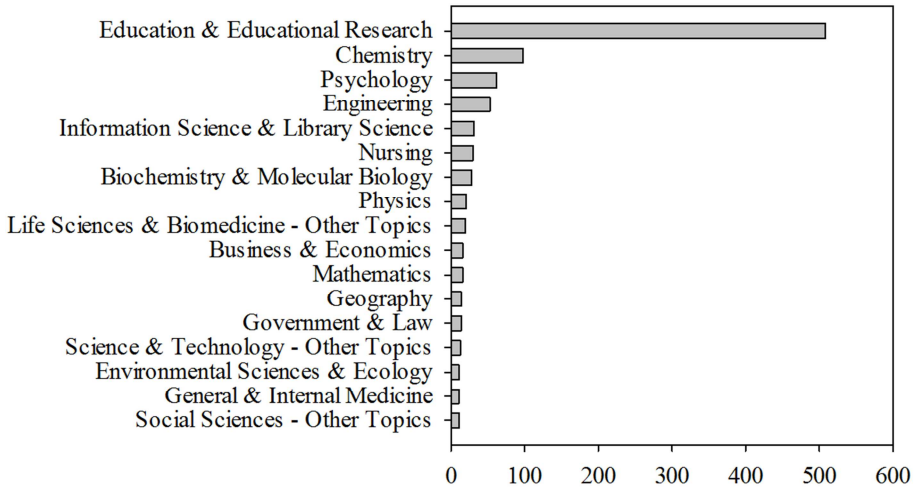

Figure 3. *Leading subject contributors in undergraduate research.*

5. Results of Co-word Analysis

5.1. High Frequency Keywords Analysis

Generally, searching keywords for research papers is a convenient way to retrieve data for studying a research field. So this paper also conducted the statistical analysis of keywords, demonstrating the most popular research topics. Table 2 lists the top 15 keywords.

In order to explore the change of research themes in undergraduate research from 2000 to 2017, the eighteen-year study period was broken into two sub-periods: 2000-2008 and 2009-2017. In the first period, upper-division undergraduate, undergraduate research experiences, stem, etc. have not yet appeared. Compare with the totality, the frequency order of keyword co-occurrence changed greatly. In the second period, the frequency of keyword co-occurrence is exactly the same as that of totality.

Table 2. *High Frequency Keywords.*

Keyword	2000-2017	2000-2008	2009-2017
undergraduate research	303	33	270
students	104	7	97
education	95	15	80
benefits	82	3	79
perceptions	70	5	65
science	68	7	61
research experiences	61	4	57
curriculum	52	6	46
inquiry	31	1	30
upper-division undergraduate	30	0	30
experiences	28	1	27
undergraduate research experiences	26	0	26
stem	25	0	25
persistence	25	2	23
faculty	25	3	22

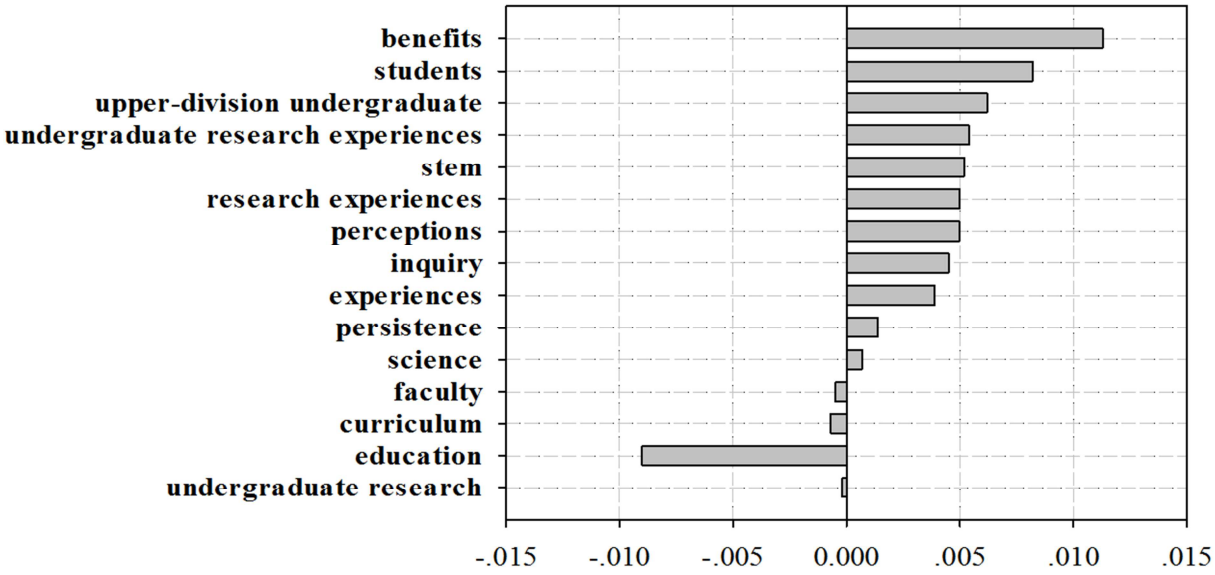

Figure 4. *High-frequency keywords co-occurrence change analysis.*

We calculating the proportion of high-frequency keywords in the total number of keywords in the correspond period, then used the proportion of the second period and the first period to do the difference, the outcome would show the change between two periods, which is showed in Figure 4. According to the Figure 4, we can see that there is a relatively low co-occurrence frequency of keywords in education, with a slight decrease in the curriculum, faculty, etc., indicating the shift of research topics. As can be seen from the Figure 4, the frequency keywords of experiences, inquiry, perceptions, research experiences, stem, undergraduate research experiences, upper-division undergraduate, students, benefits and so on have been greatly improved in the second period, showing the focus of research is moving in the direction.

5.2. Social Network Analysis

In order to explore the change of research themes in undergraduate research from 2000 to 2017, the eighteen-year study period was broken into two sub-periods: 2000-2008 and 2009-2017. The study collected all the keywords from the sample articles to conduct co-word analysis. Using the VOS viewer software, this paper visualized the relationships among the keywords and understood the changes of research topic overtime. The results are showed in Figure 5 and 6.

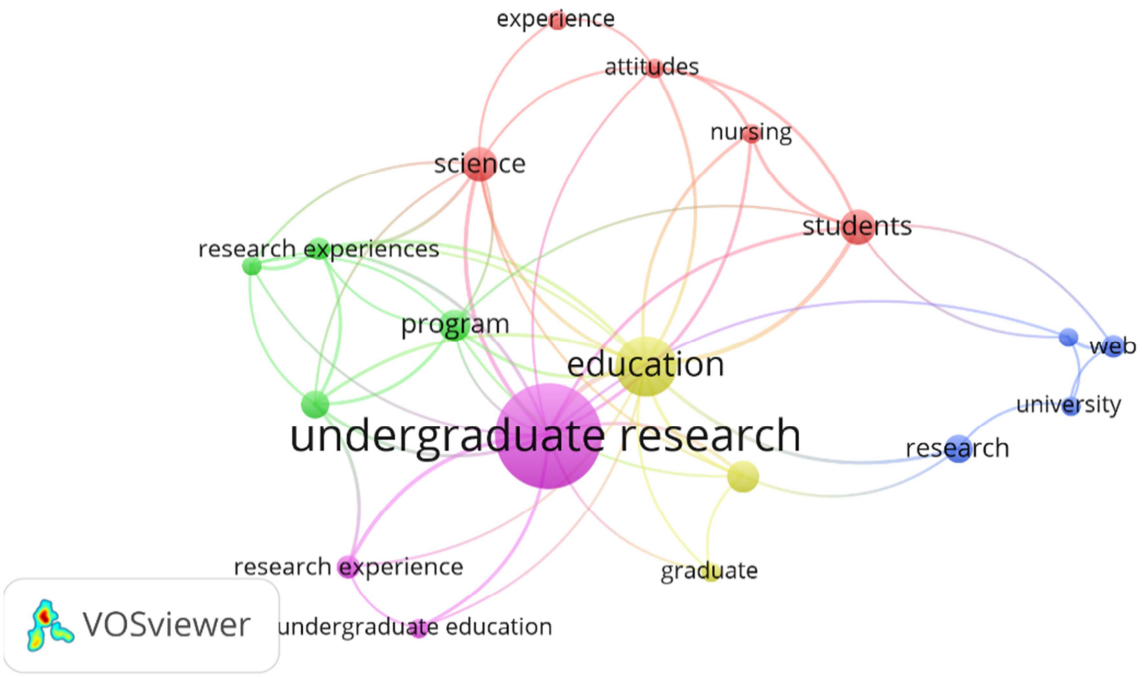

Figure 5. *Keyword co-occurrence network in undergraduate research (2000-2008).*

The study categorized those keywords that appeared multiple times into five themes in the first period. The first cluster focused on science, like Nursing, and the importance of attitudes and experience research to students. The next cluster referred to perceptions and program, undergraduates benefit from the perception of students and the design of program. The third cluster presented supporting roles, the guidance from faculty and the help of Web played vital roles in undergraduate research. The fourth cluster was identified as curriculum, focused on undergraduate research curriculum design, with the help of these, education could be accomplished effectively. The last cluster was defined as the importance of undergraduate research experience.

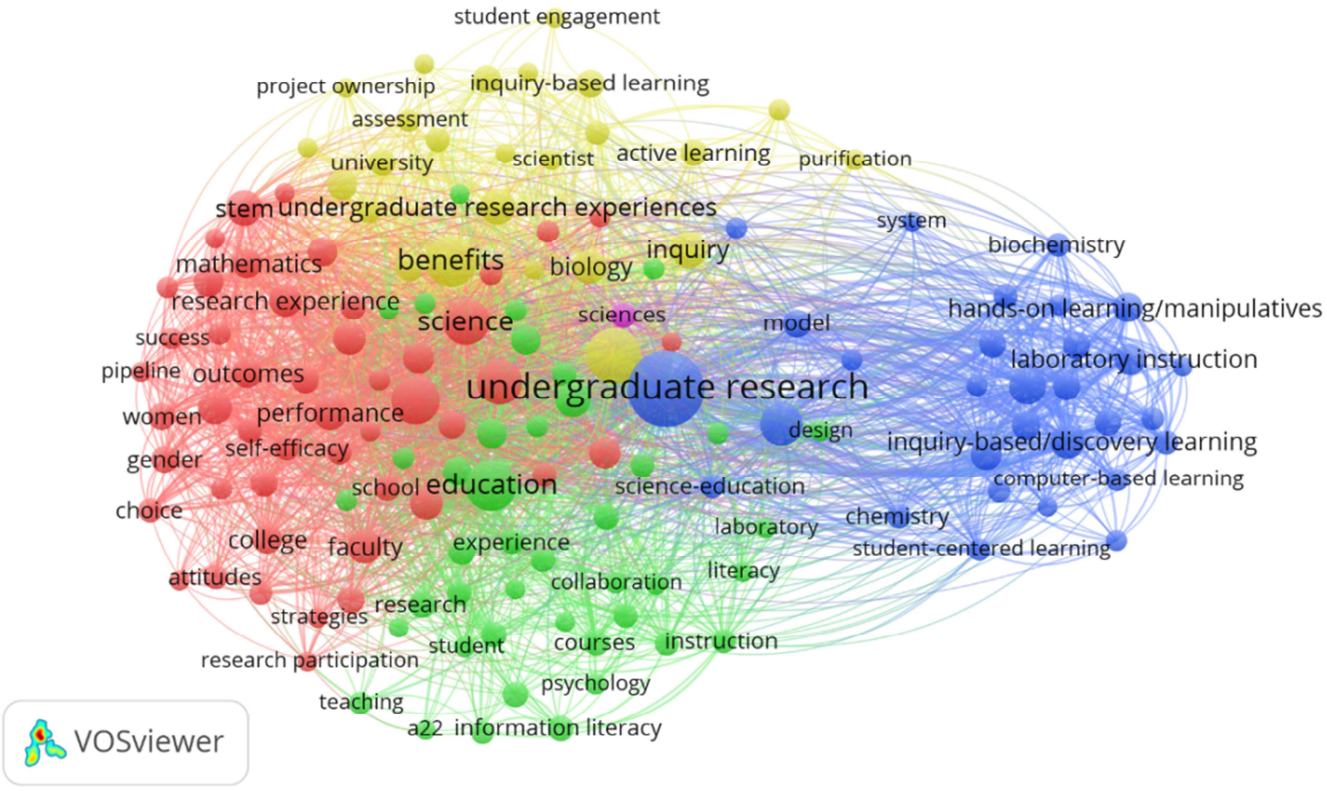

Figure 6. *Keyword co-occurrence network in undergraduate research (2009-2017).*

Similarly, the study categorized those keywords that appeared multiple times into four themes in the second period. The first cluster focused on the perception and persistence of undergraduate, which made students interested in research, especially in science, as well as, faculty mentored students' jobs, which ensured research completed. The second cluster paid more attention to the status of undergraduate education experiences in the entire educational research. The third cluster was related to Biology, in the Biology, undergraduate would benefit form the ability to inquiry and undergraduate research experiences. The last cluster presented that the research object was upper-division undergraduates and the topics were curriculum design and inquiry-based/discovery learning.

6. Conclusion

This paper investigated the academic trend in undergraduate research literature by means of analyzing the WOS database, and depicted some characteristics of undergraduate research literature from bibliometric and co-word analysis.

Bibliometric analysis proposed several findings as followings: (1) the research in undergraduate research is increasing rapidly in recent years; (2) USA contributed the first position in this field; (3) undergraduate research has been considered as an important issue in many fields.

The results of co-word analysis show that the research focuses mainly on the importance of the research, setting disciplines, experiential research, students' qualities and teachers' role. In recent years, benefits, students' grades and inquiring learning have gradually become new research directions.

Our study has got some valuable conclusion, but it is not free from limitation. This paper only uses the method of keyword co-occurrence to analyze undergraduate research, and can't fully explain the more specific content of the research topics. Future research may use the advanced and overall method to analysis undergraduate research, then can generate additional meaningful insight.

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