Research Topics and Future Trends on Maker Education in China Based on Bibliometric Analysis

Qianfei Tian, Juan Zhang, Chuan Tang, Lina Wang, Junmin Fang, and Zhiqiang Zhang

***Abstract*—Maker spaces are expanding all over the world, with the development of modern information technologies such as cloud computing, big data, open source software, 3D printing, digital sensors, distant communication, etc. Meanwhile, maker spaces and modern information technologies are transforming education to form a networked, digitalized and characterized system. This paper retrieves maker education publications from China National Knowledge Infrastructure (CNKI) Database, presents core authors and institutions of maker education research in China through bibliometric analysis and visualization methods by Citespace V, reveals three research stages, and discusses future trends of maker education research in China.**

***Index Terms*—Maker education, bibliometric analysis, Citespace V, China, CNKI.**

I. Introduction

The rise of the maker movement is closely associated with the development of modern information technologies such as cloud computing, big data, open source software, 3D printing, digital sensors, distant communication, etc. In June 2014, the former U.S. President Obama hosted the first-ever White House Maker Faire and issued a call to action that "every company, every college, every community, every citizen joins us as we lift up makers and builders and doers across the country." [1] In January 2015, China's Premier Li Keqiang toured Shenzhen's Chaihuo makerspace and declared makers "an inexhaustible engine for China's future economic growth." [2] In recent years, more and more makerspaces are set up all over the globe. By the end of March 2019, there are 2322 makerspaces listed in wiki.hackerspaces.org. [3] Fig. 1 demonstrates the distribution of the makerspaces in the world.

Maker education is an offshoot of the maker movement, which Time magazine described as "the umbrella term for independent innovators, designers and tinkerers". Dale Dougherty, founder of the Maker Faire and Make magazine, stated in his 2011 TED Talk that "We are all makers. We are born makers. We don't just live, but we make." In the same TED Talk, Dougherty also called for making to be embraced in education, as students are the new generation of makers. [4]

Fig. 1. Distribution of 2322 makerspaces all over the world.

In order to have a basic understanding of maker education development and research in China, we retrieved published papers about maker education from China National Knowledge Infrastructure (CNKI). Bibliometric analysis and visualization methods are used to present the clear pictures. Main research topics and emerging trends on maker education in China are discussed.

II. Data Source and Visualization Tool

A. Data Source

China National Knowledge Infrastructure (CNKI) (Fig. 2) is the world's largest Chinese journal full-text database, and has abundant literature resources as well as sound retrieval functions. [5] Using "maker education" as the subject words, 1976 papers were retrieved from CNKI on March 1st, 2019.

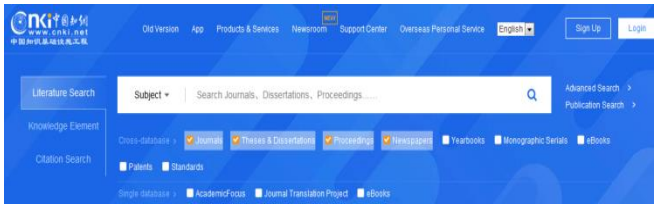

Fig. 2. Homepage of China national knowledge infrastructure.

B. Visualization Tool

CiteSpace (Fig. 3) is a freely available Java application for visualizing and analyzing trends and patterns in scientific literature. It is designed as a tool for progressive knowledge domain visualization. [6] It focuses on finding critical points

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Qianfei Tian, Chuan Tang, Junmin Fang, and Zhiqiang Zhang are with Chengdu Library and Information Center, Chengdu, Sichuan, China, and Department of Library, Information and Archives Management, School of Economics and Management, University of Chinese Academy Sciences, Beijing, China (e-mail: tqf@clas.ac.cn, tangc@clas.ac.cn, fjm@clas.ac.cn, zhangzq@clas.ac.cn).

Juan Zhang and Lina Wang are with Chengdu Library and Information Center, Chengdu, Sichuan, China (e-mail: zhangj@clas.ac.cn, wangln@clas.ac.cn).

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in the development of a field or a domain, especially intellectual turning points and pivotal points.

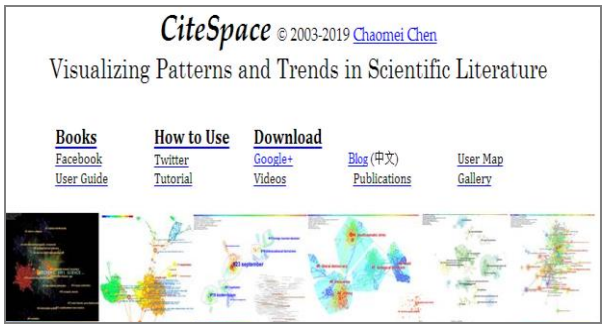

Fig. 3. Website of CiteSpace.

In this paper, we used CNKI database and Citespace V to visualize the yearly publication trend, core authors, core institutions and network, keywords distribution / network / clusters.

III. Bibliometric Analysis

Bibliometrics is statistical analysis of written publications, such as books or articles. [7] Bibliometric methods are frequently used in the field of library and information science, including scientometrics.

A. Number of Maker Education Publications

First 3 papers of maker education research in China published in the year of 2013. In the following years, the number of maker education publications increases heavily. CNKI database estimates the number would surge to 938 in 2019, shown in Fig. 4.

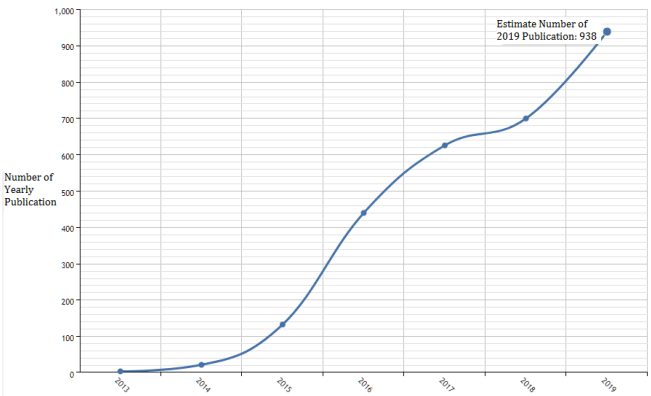

Fig. 4. Yearly publications of maker education research in CNKI.

B. Types of Maker Education Publications

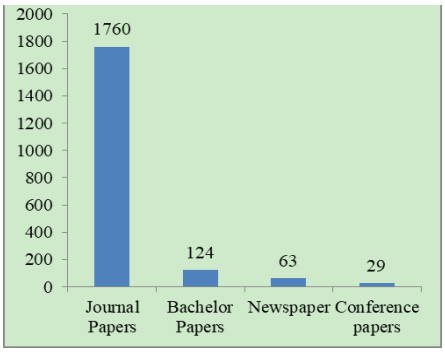

Fig. 5. Types of published papers.

As Fig. 5 shows, almost 90% maker education papers were published in journals, while some others were published in newspapers, conferences, etc.

C. Related Disciplines

More than 80% of the maker education publications focus in the subject of Education. The other crossing subjects include Library and information science, Business management, Computer, Languages, Business economy, Science of science and Sci-Tech management, Art, Ecology, and so on. Maker education research is crossing the borders of traditional education subject, and integrating into other domains. [8] (Fig. 6)

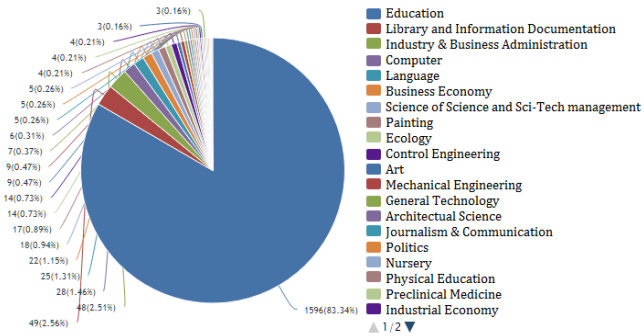

Fig. 6. Related disciplines of maker education research in CNKI.

D. Core Authors

There are 11 Authors who published more than 5 papers related to maker education in CNKI, as shown in Fig. 7. Xie Zuoru from Wenzhou Middle School in Zhejiang Province published 21 papers. Among his papers, *Differentiations of Maker Education and STEM Education* which was published in 2017, got the most citations (22) and downloads (963). The paper analyzed Maker Education and STEM Education from several aspects such as, their origin sources, contents, methods and essence. [9]

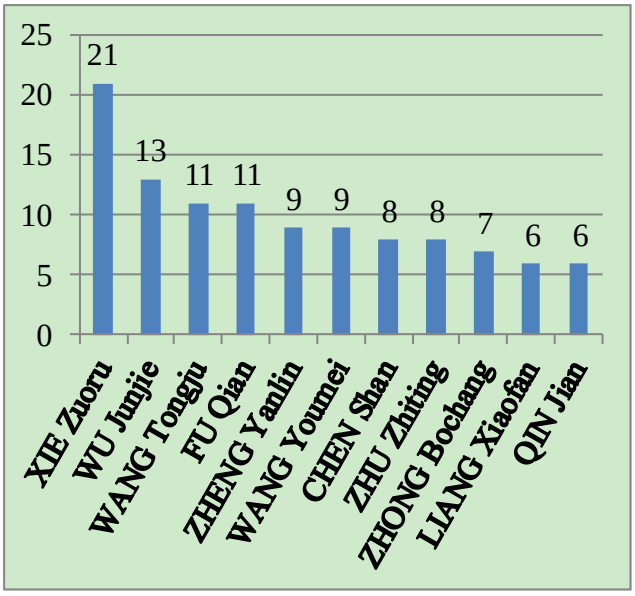

Fig. 7. Core authors of maker education research in CNKI.

One of Xie Zuoru's co-authors -- Wu Junjie from Beijing Jingshan School, published the second most maker education papers. Wu Junjie's most cited paper (citations 51) and most

downloaded paper (downloads 971) were both published in the year of 2014. The former publication mainly focused on "makers" and "future customers" in maker education [10]. The latter one introduced his/her own three years' experience in "maker education" [11].

E. Core Institutions

Fig. 8 presents 10 institutions which published more than 15 papers related to maker education in CNKI. Among them, 7 institutions are normal universities, 1(Wenzhou universith) is a comprehensive university, 1(Wenzhou Middle School in Zhejiang Province) is a Middle school, and 1(Beijing Jingshan School) is a K-12 school.

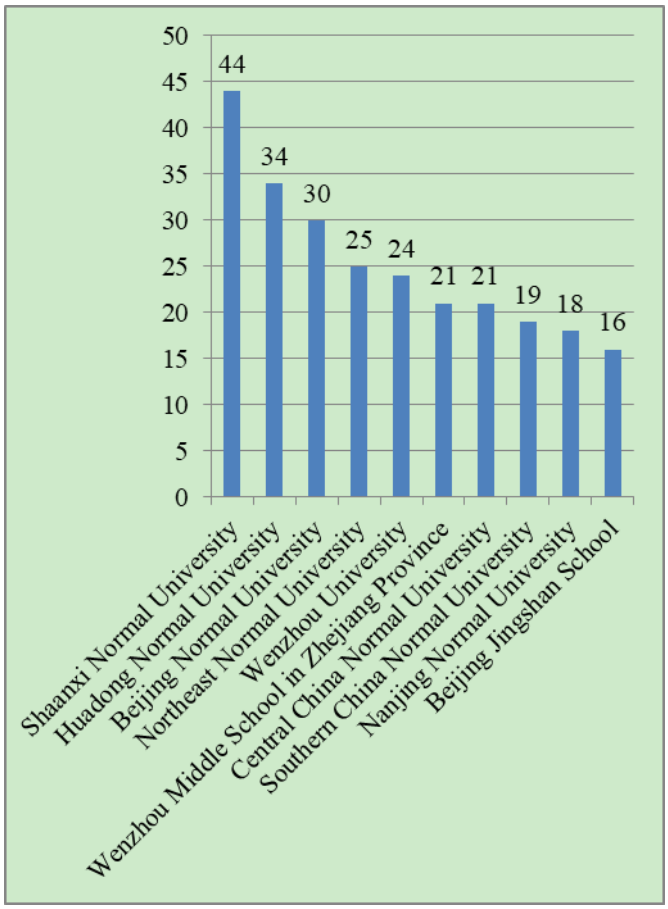

Fig. 8. Core institutions of maker education research in CNKI.

Fig. 9. Visualization of institution co-occurrence on maker education research in CNKI.

Fig. 9 visualizes institution co-occurrence. It shows 2 obvious clusters. The first cluster includes Wenzhou Middle School in Zhejiang Province, Beijing Jingshan School, etc. The second cluster includes Beijing Normal University, Nanjing Normal University, etc.

F. Keywords Distribution / Network

Based on Citespace V, keywords distribution and network visualization is presented in Table I and Fig. 10.

TABLE I: MAKER EDUCATION KEYWORDS AND FREQUENCY

No.	Keywords (Translated)	Keywords (in Chinese)	Frequency
1	Maker education	创客教育	1593
2	Maker	创客	257
3	Makerspace	创客空间	224
4	Maker movement	创客运动	62
5	Innovation	创新	54
6	Colleges and universities	高职院校	52
7	Primary and middle school	中小学	48
8	Teaching modes	教学模式	48
9	Innovation ability	创新能力	44
10	Maker culture	创客文化	43
11	Internet+	互联网+	41
12	Steam education	Steam教育	40
13	Information technology	信息技术	38
14	Innovation and entrepreneurship	创新创业	38
15	Universities	高校	38
16	Robots	机器人	33
17	Maker spirit	创客精神	31
18	Stem education	Stem教育	31
19	Maker Courses	创客课程	28
20	Innovation and entrepreneurship education	创新创业教育	28

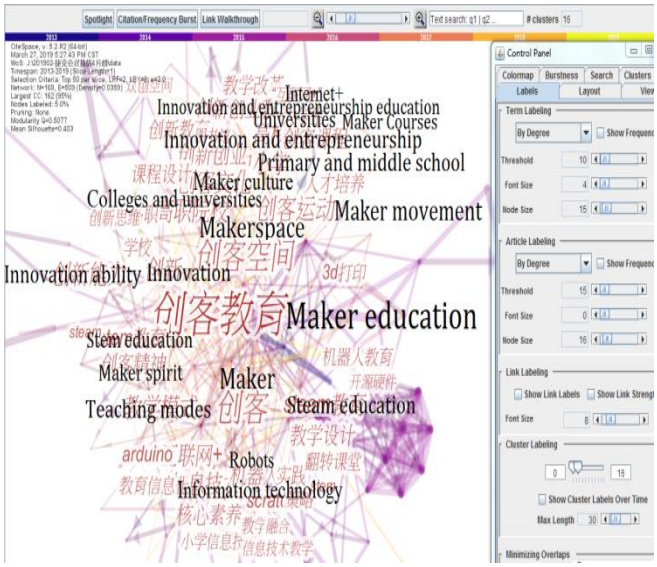

Fig. 10. Visualization of keyword co-occurrence on maker education research in CNKI.

According to Table I and Fig. 8, maker education research can be concluded into several topics. Such as, basic introduction and theory exploration on maker movement, maker space, and maker culture; difference and connection between maker education, STEM education and STEAM

education; technologies related to maker education, like 3D printing, robot education, open source hardware, and Internet+.

IV. Maker Education Research Stages and Trends

Through bibliometric analysis and literature review, we can conclude maker education research stages (Fig. 11) and trends as follow.

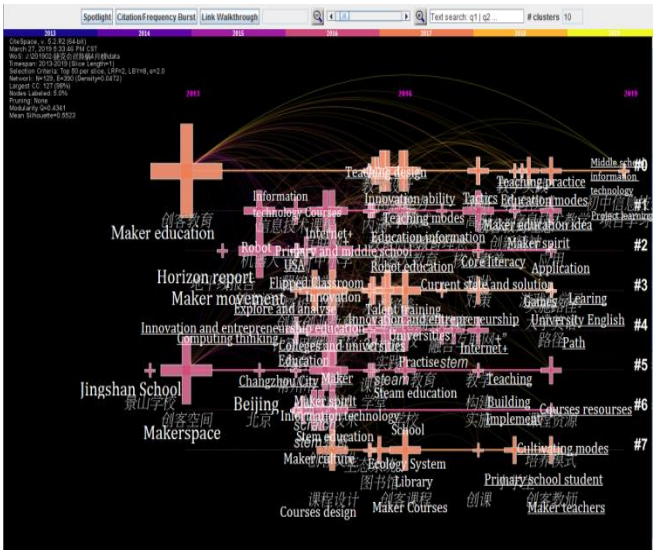

Fig. 11. Maker education research stages and topics.

A. Stage 1: Early Initial Stage (2013-2014)

Maker education research in China begins in 2013, 3 pieces of paper published in the year and 21 in year 2014. Keywords mainly include maker education and makerspace in 2013. In 2014, maker education research extended to integrate with information technology, robots, etc.

B. Stage 2: Quickly Surging Stage (2015-2017)

March 2015, the Ministry Council of China issued *Guidelines for Developing Makerspaces and Advancing Innovation / Entrepreneurship*. Since then, research on makerspaces and maker education sprung out. The number of publications surpassed 100, 400, 600 respectively in the year of 2015, 2016 and 2017. The keywords enriched a lot, including information technologies such as, scratch, 3D priting, robots, internet+, etc; education comparison such as STEM education, STEAM education, middle and higher education, etc; education resources, such as courses designing, libraries, talent training, schools and classes, etc. Zhu Zhiting and Sun Yanyan from East China Normal University, Shanghai, described maker education as a practical field of ICT-Enabling Innovation Education and concluded eight essential elements in maker education as: relevant topic, complexity, sufficient resources, interaction and collaboration, intensity, reasonable time management, sharing, and innovativeness. [12]

C. Stage 3: Advanced Developing Stage (2018-2019)

In the third stage, researchers are making the transition from concept research to practice and implementation. Keywords mainly include constructing and implementing, strategy / solution and paths, teaching modes, games and learning, applications, etc.

D. Maker Education Future Trends Analysis

Yang Gang from Wenzhou University described maker education and its role in education modes / system reform, talent training mode innovation, which reminded us to not only focus on technologies and implementations, but also research deeply on the corresponding transformation to education paradigm, including education theory structure and practice, teaching mindset, teaching and learning environment change, relationship between knowledge and courses, learning assessment methods as well as education culture and policy guidance. [13]

ZHU Zhiting, SHAN Junhao and YAN Hanbing carried out International Investigation and Developmental Strategies for AI Maker Education. The authors sorted out the education products or education services of artificial intelligence at home and abroad, and put forward strategic development suggestions from the three aspects: AI curriculum design, coach group construction, and maker space construction. [14]

LI Pengfei and ZHANG Baohui from Shaanxi Normal University concluded maker education trends in China as follow: 1) integration of maker education and STEAM education; 2) teacher training in maker education; 3) construction of maker courses system; 4) building ecosystem to support maker education. [15]

In the future, maker education research would go deeper to clarify its concept and true meaning, integrate more and more emerging information technologies (Artificial intelligence, Internet of things, etc.), compare similar concepts and education modes, shed spot light on successful maker education cases home and abroad, construct maker education system and ecology.

V. Conclusion

Through bibliometric analysis based on CNKI and visualization analysis based on Citespace V, this paper gives an overall picture of maker education research in China. Maker education is developing rapidly and gaining more and more attention from primary and middle schools as well as universities and colleges. Maker education best practices communication and co-operation would be encouraged, maker education and scheme reform would be reinforced, maker policies and funding projects would be planned and invested.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Qianfei Tian conducted the research and wrote most sections of the paper; Juan Zhang wrote the first and last section of the paper; Chuan Tang analyzed data; Lina Wang worked on visualization; Junmin Fang provided the suggestion on the topic; Zhiqiang Zhang gave suggestion on trend analysis and conclusion part.

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Qianfei Tian was born in Chengdu city, Sichuan province, China, on Dec. 12, 1985. She got the master degree in the major of computer science, from Southwest University in Chongqing city, 2009. She is a doctoral student at the Department of Library, Information and Archives Management, School of Economics and Management, University of Chinese Academy Sciences, Beijing, beginning in 2017, under supervision of professor Zhiqiang Zhang.

Since the year of 2009, she is working at Chengdu Library and Information Center, Chinese Academy Sciences. In the latter half year of 2015, she visited North Carolina University, Greensboro, under supervision of associate professor Anthony S. Chow. She got a promotion to be an associate professor in 2018. Her current and previous research interests include strategic analysis on information technology, policy and strategic analysis on science, and big data analysis in science of science.

Associate professor Qianfei Tian is a member of Sichuan Science and Technology Youth Association.