Analyzing the Dynamic Shifts of Teaching Focus in Engineering Education Using Bibliometrics

--A Case Study on Mineral Processing Major

Qianying Wu
Business school
Central South University
Changsha, 410083 China

Xiqing Wu* (*Corresponding Author*)
School of minerals processing and bioengineering
Central South University
Changsha, 410083 China
xiqingwu@hotmail.com

Genming Zhang
Business school
Central South University
Changsha, 410083 China

***Abstract*—The education contents of different engineering majors have varied greatly, and each specific major has its own discretion of professional curriculum establishment. How to objectively probe the advances of majors and make right use of this decision-making power is an essential link in the comprehensive education reform of engineering majors. The shifts of professional education focus in engineering majors were obtained by analyzing related bibliometrics. First a hierarchical classification of professional literature related to a specific major is formed, and the literature number of each group in the hierarchical classification is recorded in a chronological sequence, then the relationship between the literature number and time is established by mathematical regressions, subsequently the drifting pattern of key knowledge points within the major being deduced in the form of quantitative models, which enable us to objectively discover shifts of education focus in the engineering major and sensibly facilitate arranging curriculums and amending/compiling textbooks, modulating teaching and experiments. This method was applied in the mineral processing major.**

Keywords- engineering education; mineral processing; bibliometrics; professional education; curriculum establishment

I. INTRODUCTION

Engineering majors are mainly aimed at transferring science into industrial applications. So, engineering education is characteristic of teaching useful methods which are closely related to engineering project, process and problem-solving, and also the complexity of modern engineering projects makes it necessary for the cultivation process to change from developing simplex professional capability to cultivating the students' all-round abilities. Due to the rapid development of social economics and engineering techniques as well as various aspects involved with teaching and learning, the undergraduates now hardly achieve the original education goals and requirements, and one reason behind this is that the cultivation plan of professional skills and curriculum establishments lack interactive communications with the industry and society. The education steering committee of each major is generally composed of almost professors only, and the industry has limited influence on the educational goal, processes, and teaching methodologies. So, the engineering educations deviate from the genuine purpose of teaching in aspects ranging from educational goals to educational processes, and even the educational results [1].

In China curriculum settings of engineering majors usually include such modules as general education, basic education of engineering capability and professional education. Among these three modules professional education varies greatly with different majors, and each major has its own decision-making independently. How do we seize the development of each major and make right use of this decision-making power? As aforesaid there are defects with professional teaching steering committee, and enterprise experts are too specialized while general education theorists are too generic. This paper discovers another approach—bibliometric analysis of professional literature—to study the shift in education focus as well as the impact of this shift on professional education. Different from science and art majors, graduates of engineering major have one essential characteristic that is for them to solve practical problems. Thus, the literature concerned will normally reflect newly exposed professional problems and seek for solutions. Therefore, for engineering majors the current research literature, especially the drifting tendency of the literature related to the major within a period of time, will reflect the focus shifts in the future.

This paper takes mineral processing major as an example to illustrate the application of this method because each engineering major has its unique literature structure. Mineral processing (once known as 'beneficiation') is a technique mainly applying physical separations to extract valuable materials from mineral resources. Up to the 1960s, there had been independent engineering science systems for the main separation processes of mineral processing, such as gravity separation, magnetic separation, flotation, and so on[2]. Complete mineral processing industry should also include ore

---

*The author acknowledges the financial support from China Ministry of Education (the Comprehensive Reform of Education of Engineering majors-Mineral processing, 2012) and the National Natural Science Foundation of China (No.51274256).

handling before the separation and operations after separation [3]. Just like other engineering majors, researches in mineral processing tend to shift to engineering science and fundamentals. But as for the mineral processing education, the connection between university and enterprises cannot be overestimated [4]

Bibliometrics is a subject which utilizes quantitative methods in literature carrier analysis to uncover the historical development of certain science fields as well as authors, publications and usage information[5]. Thus, the purposes of bibliometric study concern two sides: one is to analyze the literature features of a specific discipline using quantitative methods, therefore revealing structure, characteristics and rules of a particular discipline; the other is to make clear the usage information of the literature within a specific field. Apparently, this study coheres to the former case.

II. Index System Design of the Bibliometrics and the Corresponding Curriculum in Mineral Processing

Firstly the bibliometrics needs an explicit index system of literature metrology, and one of ways to design the index system is to decompose the evaluation target. As for discipline evaluations, it is feasible to turn the target into first-level indexes, and then breakdown the index into second-level indexes, and proceed in a hierarchal order where the next level index is more specific, clearer, and with a narrower range. This process continues until the index is observable, measurable and operable, and shapes the last stage of indexes[6]. Therefore, to study the shifting direction of education focus of engineering majors the researchers should be familiar with this major in order for the index design of literature to be conducted properly, and this is why the authors chose mineral processing to carry on this case study.

Mineral processing major is the secondary discipline under mining Engineering, and according to 'Classification Code of China Library literature' under this discipline there are 6 categories (first-level indexes): theory, process and methodology, coal dressing, beneficiation of metallic ores, beneficiation of non-metallic ores, and the comprehensive use of mineral resources. Mineral processing is an engineering subject concerning processes and methods, and among the categories mentioned above, the latter 4 (coal dressing, beneficiation of metallic ores, beneficiation of non-metallic ores, and the comprehensive use of mineral resources) are the targets of study and application of the former 2(theory, process and methodology). Thus, this paper uses the former 2 types of literature as metrological subjects, and especially the subject 'the comprehensive use of mineral resources' will also be included. Then, these categories are decomposed into next second and third levels, and the resultant index system and corresponding professional teaching textbooks and course establishment of mineral processing at our university are listed in table I.

It can be seen from Table I, at present most of professional teaching textbooks and curriculums are consistent with the literature classification.

TABLE I. Classification of Literateure and Corresponding Teaching Textbooks and Course Establishment of Mineral Processing at Our Univerisity

First Level	Second Level	Third Level	Corresponding Textbook	Corresp-onding Course
TD91 theory	TD912 ore property& type		Mineralogy	Mineralogy
	TD913 ore separability		Ore separability	Ore separability
TD92 process and methods	TD921 ore handling before separation	Washing, crushing, screening, grinding, classification, mixing and pre-treatment	Ore comminution	Ore comminution
	TD922 gravity separation	8 sub-groups: jigging, table, centrifugal separation, etc.	Physical separation (gravity separation)	Physical separation
	TD923 flotation	9 sub-groups: conditioning, flotation reagents, floc flotation, carrier flotation, etc.	Flotation, Flotation reagents	Mineral flotation, Flotation reagents
	TD924 magnetic and electrical separation	Magnetic, electrostatic, high tension separation.	Physical separation (magnetic &electrical)	Physical separation
	TD925 Special separations	Photoelectric, radioactive, bacteria chemical, combined beneficiation &metallurgy, etc.	Special separation, Chemical processing	Chemical processing, Biological metallurgy
	TD926 operations after separation	Chemical treatment, de-water, sampling& inspection, disposal & comprehensive use of tailings	none	Environmental engineer-ing in mining
	TD928 plant	9 sub-groups: plant design and layout, equipment installation &maintenance, automation, etc.	Plant design, Mill automation, Computer application in mineral processing	Plant design, Process inspection and control, Computer application in mineral processing
TD98 Comprehensive utilization of mineral resources	6 sub-groups: ferrous, non-ferrous, rare and dispersed, and non-metallic, etc.		None	None
The third level can be further divided into the fourth level, and this process can also be conducted with the aid of various thesauri and keywords as well as the combination of both to further subdivide the classification into key knowledge points				

information, etc., and are classified according to 'Classification Code of China Library literature'.

III. THE RESULT OF BIBLIOMENTRICS AND DISCUSSIONS RELAED TO DYNAMIC SHITFS

This database covers more than 12000 journals and 30 million articles that were published during 1989 to present, and the articles cited are increasing at a rate of 1.5 million annually. These articles cover natural sciences, engineering, agriculture, medicine, health care, economy, education and library

This bibliometric study is based on "Chinese VIP Web database" which is well known for literature retrieving in China.

Based on index system of literature established in Table I and some of the more specific keywords involved in mineral processing, this bibliometric analysis was done step by step. Although during the operations each category was searched on a yearly basis (this process was much time-consuming and tedious), only are some of the results which are of relatively stable relationship between literature amount and time selectively shown here due to the limited paper space. This paper uses only the domestic literatures as literature retrieving resource, and does not include foreign literatures or the weighing difference among different levels of journals. The results of bibliometric analysis are as follows.

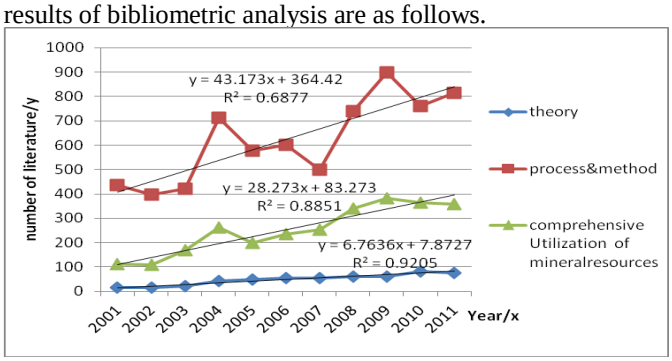

Fig.1 Bibliometric analysis of first level literature in mineral processing

As shown in Fig. 1, during the recent 11 years (2001-2011), the numbers of literature in the 3 first levels have been all steadily increasing. If a set of the points (year/X, number of literature/ Y) are regressed to fit a linear curve，and the linear correlation coefficient (R) of this set of data is larger than a certain value (here for a system of 2 variables and 11points, $R > 0.74$ or $R^2 > 0.55$ at 99% confidence level), the relation between the 2 variables can be described by linear relations based on statistical analysis (the following figures all use similar regressions and judgments)

Therefore, it can be seen that among the 3 fields (theory, process and methods, and comprehensive utilization of mineral resources) in the first levels the numbers of literature are increasing linearly annually although this is not the case for the total literature in mineral processing as a whole (not shown in Fig. 1). This enlightens us in 3 ways: A. the 3 directions of mineral processing are steadily moving forward, among them the Theory study is growing at a slow rate and its literature amount is relatively small as for some established classical theories of this major there is now little study. However these theories are not insignificant or obsolete. So when using bibliometrics to study the dynamic shifts of education focus in engineering majors it is important to pay special attention when drawing conclusions; B. the Process and Methods is prevalent and the literature number is huge, and increasing at a fast pace which also complies with the definition of mineral processing itself which mainly deals with process and methods of engineering science; C. a surprising finding is that the comprehensive utilization of mineral resources has formed a steady research front and is developing relatively fast, and as for the curriculum settings and its teaching textbook there is defectiveness (see Table I). So it is suggested to establish a course of the comprehensive utilization of mineral resources in undergraduate curriculum and compile the corresponding textbook and syllabus.

The number of literature in the group 'Process and Methods' is large as the scope of the group is also extensive (in Table I, this group is divided into 7 second-levels). From Fig. 1 it can be observed that the number of literature in this field has a relatively weak linear growth relation, and this may be caused by the fluctuations in so many smaller categories. Classify this group into second-level indexes and conduct bibliometric analysis further. There is no linear relationship between literature number and time in the cases of some second-levels, such as Ore handling before separation, Special processing, Operations after separation and Plant, and the result of bibliometric analysis for the three major separation methods (flotation, magnetic and gravity separations) is shown in Fig. 2.

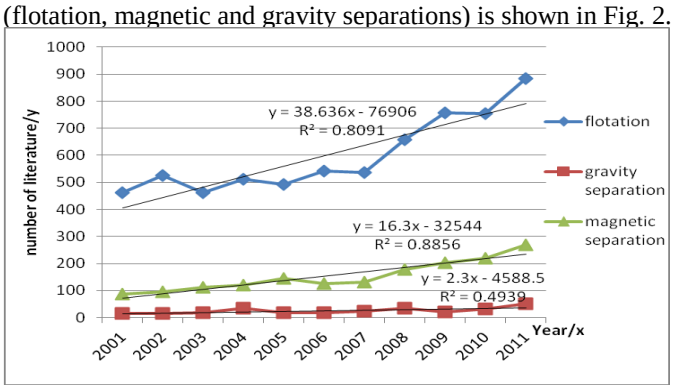

Fig. 2 Bibliometric analysis of second-level literature in separation methods

From Fig. 2 it is clear that in terms of literature number, the Flotation is the most active among the three main separations, and the Magnetic separation follows while the Gravity is the least active. Besides, according to correlation coefficient R of the linear regressions, for the Gravity separation the relationship between literature number and time does not apply to stable linear growth (correlation coefficient $R^2=0.4939<0.55$) while for the Flotation and Magnetic separations the relationships do follow linear track. The other classifications at the same level (second level), such as the Ore handling before separation, the Special processing, the Operations after separation and the Plant behave the same as the Gravity separation, and don't show stable linear growth relation between literature number and time (not shown in the figure). Thus, when arranging courses and class hours related to these three separation methods, it should be noted that the focus should be on the Flotation and Magnetic separation whilst the Gravity separation can be put in a less importance.

The third level and the fourth level (not shown in Table I) of the literature can be obtained and expanded by classifying the upper levels or even by combining some keywords or theme words to further specify some professional key

knowledge points, producing many more detailed items that need special attention during teaching process. Some results of bibliometric analysis with stable linear relations are shown in Fig. 3, Fig. 4 and Fig. 5 in order to exemplify this method.

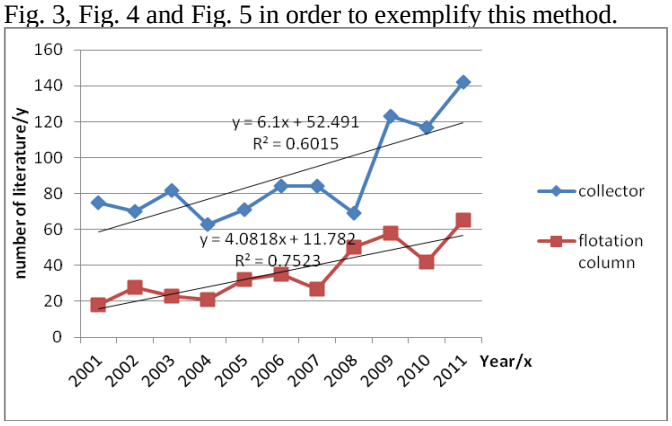

Fig. 3 Bibliometric analyses of third-level and keywords (1)

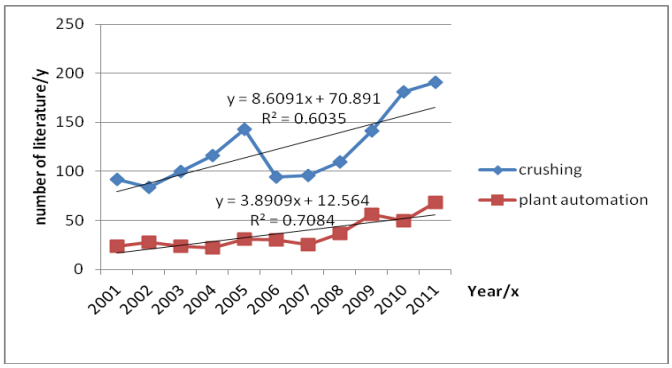

Fig. 4 Bibliometric analyses of third-level and keywords (2)

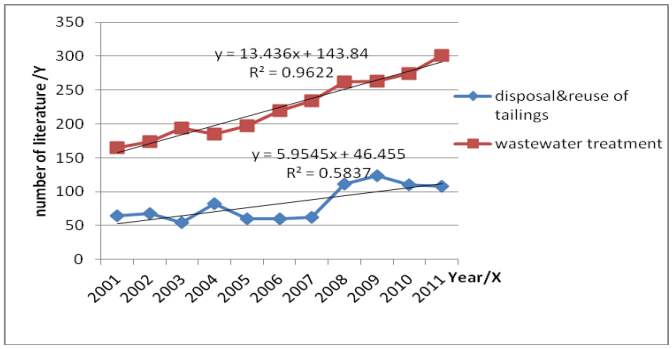

Fig. 5 Bibliometric analyses of third-level and keywords (3)

From Fig.3, Fig.4 and Fig.5 it can be seen that some upper levels (second level classifications) didn't show significant linear correlation between literature number and time but there are better linear correlation when using third level classification or keywords. These stable linear relationships give us the following suggestions when arranging teaching, compiling textbooks and setting curriculums: the number of literature in the Plant automation is in steady linear augment, thus there can be no ignorance of this course; as with the course 'Ore comminution' the part 'Crushing' should be strengthened; and there were too little introduction of the Flotation column in the current textbook 'Flotation', and furthermore the Collecting reagents as a key point in the course ' Flotation reagents' should be paid more attention to; in the course 'Environmental engineering in mining' the Mine wastewater treatment should be addressed in more detailed manner; also while compiling the 'Comprehensive use of mineral resources' course as above mentioned the comprehensive utilization of tailings should be considered as an important part. In addition, there is a need for adjusting the corresponding experiments for undergraduates in terms of the above trends.

If other extra key words are bibliometrically analyzed in the same way, there can be many more indications for us according to the changing tendency of literature. Furthermore, appropriate combination of key words can explore the tendency of cross disciplines (or directions), but will not be further discussed here.

IV. CONCLUSIONS

1. A method studying the shifting directions of engineering education focus based on bibliometrics is introduced, that is, firstly classify the literature of a certain engineering major by hierarchical order, biliometrically analyze literature of each hierarchy within a period of time, establish mathematical regression models between literature number and time, deduce the shifting tendency of direction or key knowledge points within the major, objectively discover the shifting direction of engineering education focus, and then rationally establish courses, compile textbook, moderate teaching and experimental arrangements, develop new experiment projects, and even adjust the emphasis on certain key teaching points. This quantitative drift in tendency efficiently avoids the blindness in establishing professional courses and curriculum.

2. Based on the major--Mineral processing, this methodology is specifically exemplified, and resultantly derives some conclusions: establish a new undergraduate course 'Comprehensive utilization of mineral resource'; the course 'Plant automation' cannot be ignored; the three leading separation methods should be arranged on an order of decreasing importance of the Flotation, the Magnetic separation, and the Gravity separation; and also there are some suggestions for compiling courses such as 'Ore comminution', 'Flotation', 'Flotation reagents' and 'Environmental engineering in mining'.

REFERENCES

[1] Gang Wang, "The reform and practice of engineering education mode", Higher Engineering Education study, 2011, (01):28-32.

[2] Yuehua Hu, and Wang dianzuo, "The development of subject mineral processing—history, present and future", Mining and Metallurgical Engineering, 1999, 19 (01):3-6.

[3] B. A. Wills and T. J. Napier-Munn et al, WILLS' Mineral Processing Technology, 7th edition, 2006, Elsevier

[4] A.J. Lynch, "Mineral processing beyond 2000—education for new technology", Proceedings of 18th international mineral processing congress, Sydney, June 23-28,1993:21-25.

[5] Dagang Feng, "The history and interpretation of bibliometrics", Shanghai Scientific Translation, 1988,(03):33-36.

[6] Lin Dong, "Using bibliometrics to evaluate discipline", Journal of information, 2009,28(09):65-6.