Application of Bibliometrics in Technical University Libraries

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By the science of science by scientometrics (1) is meant the application of exact measuring methods in the investigation of scientific systems. In this, measuring (2) is the member connecting observation with mathematics and allowing the formulation of quantitative theories. In the individual scientific systems there developed subjects of research dealing with metric methods - in chemistry stoichiometry, in the biological sciences biometrics, in sociology sociometry. The scientific systems dealing with the registration and evaluation of printed publications play an important part in the success of scientometric works, because the results obtained in the course of development of the sciences have mostly been stored in publications.

1. Definition, history and tasks of bibliometrics

By 'bibliometrics' the author wants to designate a field of research of quantitative analysis and measurement of the documents used for recording and communicating scientific knowledge as well as the application of statistical methods in library and information science operations (3). In so doing, the author enlarges the scope of bibliometrics deliberately by library statistics, because it is also a metric method and must therefore not be left outside this consideration.

The term bibliometrics is extraordinarily to the point and easy to understand, because not only comparable designations are known in other scientific disciplines but for comparison the super-ordinate term 'scientometrics', 'naukometriya' and 'Wissenschafts-Metrik' used in the English, Russian and German languages can also be referred to. In the international library science literature the term 'bibliometrics' has been generally used for about three years; it has also entered lexica and abstract journals. In 1969 it was used for the first time by Pritchard as 'application of mathematical and statistical methods to books and other means of communication (strongly restrictive)' (4) and replaced the restrictive term 'bibliographic statistics', which was probably first used by Hulme in 1923 (5) and which was also used by Gosnell (6) and Raisig (7).

The few available bibliometric investigations made from 1920 to 1945 resulted in findings more or less accidental and valid only for a few fields of work (8), whereas bibliometrics was given a fresh impetus by the development of the science of science and its special field of scientometrics (9). This advance can also be documented by the use of computer plants for bibliographic and library science analyses, the application of various library methods in almost all library fields as well as numerous bibliometric publications up to the organization of a first congress on 'Scientometrics and bibliometrics in planning and research' in 1976 (10).

It is common practice today to measure in the individual scientific disciplines the following parameters of the scientific potential:

1. Published papers and number of authors of published papers
2. Citation of published papers
3. Time budgets
4. Number of staff as well as size and composition of collectives
5. Funds granted or spent, buildings, devices, plants and machines

6. Visible tendencies and trends important for the future development.

These parameters and the regularities in library and information work form the basis for the tasks of bibliometrics.

The sources of bibliometrics for the execution of the tasks are:

1. Published work, mainly in the form of original papers, citations, literature compilations and reference books
2. Records of the use made of published works
3. People and the result of their work, mainly in the form of time studies
4. Questioning of individuals and of groups of people
5. Other sources, mainly records, compilations and lists of contents of published works.

2. Methods and tasks of bibliometrics in technical university libraries

So far a classification of bibliometric methods and tasks has not been made. Certainly this is not possible because every year a lot of new experience is added to this young discipline. And there do not exist any uniform conceptions of the complex application of bibliometrics and its importance in technical university libraries. The author makes an attempt at investigating some universal conceptions, laws, methods and techniques concerning their application to this type of library.

2.1. Planning, administration and organization of libraries

Bibliometrics is an important aid in long-term planning of library projects, operative planning of library work, the administration of libraries as well as in the rationalization of daily work in the internal range and with the users.

An important method is time budget research as a statistical technique for investigating the working conditions and way of life of the staff and users of technical university libraries.

This time budget in its entirety is not yet the subject of bibliometric studies. The results available are mainly concerned with internal ranges of work (department of processing and department of use). It is easy to enlarge them by extensive studies of the time consumed by scientists for literature studies, and thus, they affect the needs of information, habits of information, work in libraries as well as the benefit and expenditure of work in information services. Some results of such analyses can be found in the literature about science of science; there the starting point is the staff structure of the science potential (11).

For the future library work of technical universities it is necessary to follow corresponding trends of development. Besides the too rarely used Delphi method (12) it is very important to pay attention to the precursory potential (Vorlaufpotential) commonly used in socialist science; in socialist prognostication there belongs to the most important information-theoretical and logical foundations of forecast formation also the property of the scientific information flows to throw light upon the way to the immediate future, i.e. to dispose of this or that precursory potential (13). Here, library and information work is deliberately made a constituent of a founded prognostic investigation. This interesting concept has scarcely been taken into consideration by library science. The various kinds of information sources possess a different quality as precursory potential. Thus, textbooks and handbooks are of use exclusively for the process of education, training and continued education and are of subordinate importance for the development
of science. On the other hand, publications of firms, patents, research and development reports, reports on travels and articles in certain periodicals must be given great importance in the determination of future developmental trends, particularly in technical libraries that dispose of these sources. It is possible to determine the precursory potential more closely by means of information models (14). Here bibliometric methods set in, especially with models based on patent information, flows of scientific publications and interdisciplinary interaction.

Library statistics as the application of mathematical-statistical methods in librarianship (15) comprises also manifold possibilities for planning requirements (e.g. quantitative and qualitative development of the use made of the library), capacity planning (e.g. staff, material-technical basis, funds) and cost-profit investigations (e.g. ratio bookstock: students). This is supplemented by statistical methods in library organization (e.g. internal processes) and the standardization of various operations (e.g. duration of processing). Thus, the oldest mathematical-statistical method in librarianship proves indispensable, especially for decision finding by the head librarian. This was proved in the socialist library science. There are, mainly, applied descriptive and illustrative statistics but also variance analysis, factor analysis, parameter-free statistics and multivariant analysis. Moreover, library statistics is connected with the methods of operations research (particularly the queueing problem and the Monte-Carlo method).

2.2. Bookstock building and supply

For the building of a real bookstock and the supply of this stock bibliometrics is an almost ideal field of activity (16) because its proper purpose - the measurement of the documents used for recording and communicating scientific knowledge - here becomes distinctly visible. This concerns particularly

- the acquisition of books and periodicals: analysis of the use made of the library, analyses of citations from primary and secondary literature, analyses of reviews, analysis of inter-library lending

- using books and periodicals: analyses of citations from primary and secondary literature, analysis of attendance of library

- ratio of acquisition to lending: citation analysis of primary and secondary literature

- duration of storing books including second-hand acquisition of books: citation analyses from primary and secondary literature, half-life period.

Besides traditional library statistics, which uncovers only part of the problems and offers solutions to them, a new bibliometric course should be pursued here, which is especially practicable in technical university libraries.

In the first place Bradford's law should be pointed out. Bradford found that all periodicals could be arranged in concentric zones of decreasing productiveness as regards publications in a certain field of science (17). The number of periodicals in each subsequent zone increases, but their productivity decreases correspondingly. The law runs: If scientific periodicals are grouped according to the number of articles of a certain special field they can be divided into the nucleus and several zones containing the same number of articles as the nucleus, so that the ratio of articles in the nucleus and in the individual zones will be 1 : n : n^2 (18). Bradford's law is of great practical importance for recording stocks of periodicals on natural science and technology and the organization of information services. It has been proved that the law can also be applied to other sources of information (19).

Also the concept of half-life of literature can be closely connected with Bradford's law. By this we understand the period in the course of which half of all information sources of a field of knowledge usable at the present moment are published. The application of these problems in socialist library science - at least in library work - is disputed (20), e.g. in disposing of books from stocks of preserving libraries and libraries with special stocks.
as well as in the application outside the literature category books and outside natural science and technology.

The analysis of publications is a wide bibliometric field of work. Measured and compared are, in general, the amounts of published works per unit of time according to single information sources in individual disciplines of science. The basis are various information sources, particularly abstract journals. The graphs often show the curve of an e-function. This phenomenon is based upon the law of the accelerated development of science formulated by Engels (21) and changed by workers in the field of science of science into a mathematical expression; this law gave rise to frequent discussions (22). The information at the disposal of mankind (not scientific cognition as is often maintained in a superficial way) - integrated over all ranges and independent of all jumps and stages - will double within short periods of time, e.g. every 10, 8, 5 and 3 years; half of all results of science available at present were obtained within the last 15 years. In the application of this law American scientists start from the unchangeability of all developmental conditions of the sciences, negate changes in the social structure and in no way take into consideration the basic law of dialectics, according to which quantitative growth inevitably will result in qualitative changes. They prematurely draw limits of saturation and partly arrive at strange conclusions concerning the development of science. Scientists of the socialist countries recognize this law as general tendency and investigate the single sciences in their concrete historic conditions. It is only in this way that the amount of published work can become the starting point of bibliometric analyses and contribute to the confirmation of the laws of development. Viewed from this side the stocks in technical libraries are also of great importance. Examples are:

- the volume of literature in a technological discipline
- the linguistic distribution of publications and effects on the evaluation of the information contained in them (23) ratio of volume to contents with scientific papers (e.g. theses) and volume and kind of information sources of bibliographies up to the age structure of information sources used in journal articles
- delay of publication terms with technological books and journal articles (date of delivery of manuscripts up to printing of the publication)
- dependency of the number of orders of single information sources and the age of these
- number of authors of publications (the tendency of collective co-work within the technologies).

In 1963, with the journal 'Science Citation Index' a new type of bibliographical register - the citation index (24) - was created, which, because of the mainly evaluated information sources of the natural sciences and technology, is of great importance for technical university libraries and their users. By 'citation index' a means of information is meant that contains a compilation of bibliographical data about scientific works, which follow the appearance of the original work and refer to this original work or quote it. This way is reversed as compared with the search method common so far and is very important for scientific work. It is thus readily possible to trace the propagation of ideas and their practical application in one's own and other disciplines of science. Also typical lapses of time of citation frequency of single scientific papers can be calculated. Therefore, citation indices - besides the indicated applicability in the library practice - play also an important part in science history and forecasting.

2.3. Bookstock supply and problems of information/documentation

Empirical working methods are more and more supplemented and improved by bibliometric methods (25). The following examples and explanations show further, especially future applications of bibliometrics taking into special consideration technical libraries and information and documentation work in the fields of science and technology (26).
The subject of combinatorics is the arrangement and compilation of elements of an amount. It is of great importance in setting up key systems for punched cards and punched tapes.

Mathematical statistics has a main task, starting from n results of the observation of a mass phenomenon, namely to yield scientific findings about the condition of this phenomenon. The main field of application is the information store, e.g. thinning as well as the problem of store maintenance.

The algebra of logic (Boole's algebra) is the teaching of connecting variables representing decisions between two states. It is applicable in using electronic data processing in information/documentation and for setting up a search strategy.

Probability calculus (probability as a measure of the mean frequency for the occurrence of an accidental event) can be used among other things in setting up information centres (Markov chains) (27). Here, also simulation can be used; that is in cybernetics and mathematics the imitation of properties of one system by another.

Various techniques may also be used in making and optimizing thesauri (28), in the determination of the ratio of stock of words to text size with publications and in the publication behaviour of authors.

The number of authors per publication, citation indices as well as time budget studies with lapses of time within the individual departments are, of course, applied here too.

3. Limits of bibliometrics

Mathematization of the sciences is advancing (29); by process also library science, bibliography and informatics are 'infected', although the 'incubation period' is sometimes rather long. Young bibliometrics as the application of mathematics to the just named disciplines is just becoming an independent subject of teaching and research. Its limits are the same as those of the mathematization of the sciences in general: the means of mathematics can be used fruitfully (30) only in connection with other methods of cognition; quantification alone is not sufficient.

The application of general bibliometric principles to the library stocks is still (and may remain so forever) problematic; for it is a long way from recognizing the half-life period of literature, general judgements as to value of publications and available citation analyses up to their realization in library practice, especially by weeding out literature from the library stocks.

It must be taken care that not any petty matter in the daily work be measured with the yardstick of the 'bibliometrician', and bibliometric results cannot be expected with projects of small size and a high percentage of political, pedagogical, psycholgical and sociological tasks. It is the practical value of the bibliometric result that is decisive.

4. Conclusions for the promotion of bibliometrics

Bibliometrics has its - though not yet clearly defined - place in library science, bibliography and informatics. To promote it in a reasonable way belongs also to the tasks of heads and staff of technical university libraries. And the promotion must begin with the popularization of the contents and teaching of basic knowledge. That means that the conveyance of knowledge, abilities and skills concerning bibliometrics has to be admitted to the educational plans and it will become an immanent constituent of the science of science and library science. This demands openmindedness towards mathematization and rationalization of scientific work, for bibliometrics with its various methods will contribute to organize scientific work better and to make it more effective. But that also means that besides the librarian there must be the mathematician (nor does the librarian build his library; he only believes so and writes about it in special periodicals), who together with the library staff progressively pushes bibliometrics forward.
The library of a technical university is almost predestined to support the advance in science, for it administers and propagates the enormous fund of literature of science and technology developing so impetuously (by the way, according to bibliometric laws). The staff of this type of library is thus from the very beginning open to every novelty: it needs often only an impetus from outside, mostly by a colleague of another scientific discipline.

References


