

1. Methods

Teaching Information Science Students for the Use of Different Methodologies

Fernanda Martins¹

¹Faculdade de Letras, Universidade do Porto, Portugal

Abstract: The Information Science course of the University of Porto in Portugal has a learning unit designed Research Methodology. As a teacher of this discipline I encourage students to develop research studies using either qualitative or quantitative methods applied to possible future professional scenarios, namely when analyzing librarians' users satisfaction. The aim of this communication is to present some examples of those research essays and to discuss future ways for teaching and learning those issues as well as different professional frames where those methods are needed to solve problems.

Keywords: Librarian students; Information Science Students; Teaching quantitative methods; Teaching qualitative methods; Librarians' users satisfaction.

1. Introduction

Since 2001 the University of Porto in Portugal has an Information Science course that resulted from a partnership between Faculty of Arts and Faculty of Engineering. It is based on a large and integrated perspective considering subjects of different interdisciplinary areas and is organized according to the spirit of Bologna Declaration in what concerns professional profiles and competences (Ribeiro, 2005).

The curriculum design supposes that technical procedures of information's representation (such as description or classification) are a part of any information system, namely archives or libraries. This unitary perspective also aims to synthesize the so called Information Systems (technological systems devoted to the storage and retrieval of information) that are increasingly implemented inside organizations in general. Thus, learning contents include: (1) theory and research methods, (2) systems analysis, (3) technical procedures for organizing and representing information related to storage and retrieval, and (4) informational seeking and behavior. Complementary subjects include applied components of Information Science related to the different kind of information systems (archives, libraries or technological information systems). This Information Science course has a strong technological component and is oriented to information management problems in any organizational context (Ribeiro & de Pinto, 2009).

The main goal of the Bologna Process is to be capable of creating until 2010 a European Higher Education Area making it possible for students to choose from multiple high quality courses and have easier recognition procedures with comparable degrees across Europe. It supposes the idea of an educational system based on the development of competences rather than on the transmission of

2 *Methods*

knowledge and is planned for a lifelong learning and development. It meant a total reorganization of curricula and teaching methods in every cycle of study in order to development of a reformed and modernized system.

In order to fit these new educational ideas, either the general curricula of courses or the particular learning activities proposed in each discipline had to be modified. If the system is supposed to develop competences it has to tell what a graduate of an education must be able to do in order to graduate. This also means students must show in action that they are competent, that is, that they are able to interpret the situation and have a repertoire of possible actions to choose which have been trained and were previously found to succeed. Regardless of training, competence grows through experience and the extent of an individual to learn and adapt.

In the same sense, the fast development of working life and technology requires an equally fast development of competences and knowledge which implies a lifelong learning carried out in close cooperation with the education system, and society.

The new educational challenges are, in some way, related with some classic pedagogical issues: (1) the importance of learning by doing, (2) the need for learners to take the responsibility of their learning and (3) learner-centered model. In reference to the first aspect, Jerome Bruner following the ideas of Dewey and Piaget proposed the so called discovery learning a constructivist approach to education and states that discovering for oneself teaches how to acquire information making it more ready in problem solving (Bruner, 1961). However Mayer (2004) points out that more important than being behaviorally active is to be cognitively active. The discovery learning is also a method of instruction through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments.

Finally according to the learner-centered model (McCombs & Whisler, 1997) learners bring to the learning process diverse references as a consequence of their previous experiences. To learn is seen as a constructive process that is facilitated when learning issues are relevant to learners and when they are actively involved creating their own knowledge and comprehension putting together their previous knowledge and experiences. Teaching methods must attend students' goals and promote the self regulation learning through experiences of self regulated teaching and learning.

2. The discipline of Research Methodology

As already said the Bologna Declaration obliged curricula to include aspects of some similarity all over European countries and to implement the development of professional competencies which was also the case of this Portuguese Information Science course. This course has a learning unit designed Research Methodology that has as fundamental objective to prepare students in order (1) to adopt a critical attitude toward professional problems (2) to question the logic of the social processes of scientific production, (3) to characterize and to apply different methodologies in the scientific production of Social Sciences (4) to critically apply and analyze different data collection instruments (5) to know and to apply formal norms for research presentation. Students must also (1) know scientific research

fundamentals, (2) develop a critical and creative spirit when confronting problems related with their future profession (3) present skills for team work, (4) develop skills for organizing and presenting individual work and (5) organize and plan research work based on acquired knowledge.

One of the main objectives of the discipline of Research Methodology is to develop research competencies on students through the planning of short research studies where typical methods of data collection and treatment used in Social Sciences are applied. To be capable of doing research planning, data collection and treatment and to know how to write and present research results means students have learned by doing.

As seen before authors point out the importance of developing competences by doing and this way students measure their difficulties and can update their theoretical knowledge in order to accomplish their work. This application component of the discipline is based on: (1) theoretical aspects of research planning steps, namely documental research, (2) data collection methods (observation, interviews and surveys) and (3) data treatment methods (content analysis and statistical methods using statistical analysis software). All these aspects are usually present in Social Sciences some in qualitative and some others in quantitative research. Special importance is given to the construction of surveys and to the use of interviews in data collection as well as to the application of statistical methods with the use of the SPSS software. Among qualitative methods the one proposed by De Bruyne (1974) in which evaluation is based on four poles or elliptical stages (epistemological, theoretical, technical and morphological) is presented as an alternative that fits the needs of a qualitative research. Some colleagues of the teacher team (Silva & Ribeiro, 2009) have already used this method to study information evaluation seen as a methodological operation, and applied to information in any context of production and use, in the scope of Information Science. In that study authors proposed criteria and parameters in order to apply evaluation taking into account the information's life cycle, the renewal and obsolescent of knowledge and the importance of memory for the long time preservation of informational products.

In this learning unity students, as already said, develop some research studies applying the methodology proper of Social Sciences. This means that most works focus on the opinion of information users either it is related with libraries or any other context of information use. Once one of the possible Science Information professional careers is related with libraries, the objective of this paper is to present some examples of students' work related with libraries' context.

In the great majority of the works students choose to use a survey as it is an easier and more rapid way of obtaining data than it is interview, for instance, and it allows applying statistical methods. Both issues are felt as important needing some training in order to be able to use them in the future.

Some of their studies are presented below and some methodological aspects are referred namely the main objective, the participants, the data collection method and the main results and conclusions.

4 *Methods*

Study 1(1)

This study aimed to understand the degree of knowledge showed by the users of the library of the Faculty of Arts and Humanities of Porto, namely, the familiarity with the electronic resources available and their regular use. It also analyzed if those resources are public and used by them.

The information collected during this research work corresponds to a sample of 127 Library users of the Faculty of Arts and Humanities of Porto (FLUP). An inquiry comprising 15 questions was given to this sample of the library users. Its aim was to understand to what extent the academic community is familiar with the use of electronic resources.

The inquiry is composed of four major points: (1) characterization of the interviewees regarding gender, age and academic qualifications, (2) the interviewees' general information technology knowledge, (3) direct and objective answers about their concrete knowledge of what electronic resources are (this question was later object to a content analysis). The library users were also asked if they were aware of which electronic resources were available, they were asked to express if they felt the need of attending training courses to fully use the available resources, and how they learned about them and (4) different electronic resources available in the library were listed and interviewees must answer about their knowledge and importance given to these resources, as well as about the frequency of their use.

Results showed that age, gender and academic qualifications are important to determine the interviewees' degree of knowledge and how they use the electronic resources available also affecting the importance users give to the presence of those resources.

Although the library made a considerable investment in new technologies in order to provide different electronic resources the potential of these tools is still far from being fully explored. However there is a continuous development and promotion of the library's electronic resources.

Study 2

The aim of the study was to know the degree in which students of both Faculties (Engineering and Arts and Humanities from the University of Porto) were opened to the existence of e-books and other digital documents and to point out the possible differences between Faculties.

A survey was presented to 40 students, 20 from each School. Responses were given to sentences in a 5 point scale from totally agree to totally disagree.

Results showed that students didn't know much about e-books, especially about the free availability of them on the Web. However a great percentage read books (60%) although not digital ones (only 20%) but in the Library (60%) and know few digital Libraries (only 20%). There were no differences statistically significant between Faculties.

Study 3

This study analyzed the differences between a random sample of 50 students from

the Faculty of Arts and Humanities in their use of Libraries. Some differences between courses were found but the main differences were between sexes. Female students go to the Faculty Library more frequently than males.

Study 4 (2)

The aim of the work was to know which methods of information research, first year university students from some Faculties of the University of Porto use in the first place when they have to make a research, namely the Internet versus the Library.

A questionnaire was constructed for the aim of the study and was presented to a sample of 20 students from each of five faculties (Arts Faculty, Engineering Faculty, Law Faculty, Science Faculty, and Medicine Faculty) in a total of 100 surveys.

Generally students prefer the Internet to search the information needed for their studies although the vast majority of respondents know that the information from that environment is not always reliable or valid. University students of the first year prefer to make research on-line saying that it has the capacity to catch more information and to accede to an enormous number of contents in a fast form. However, students prefer Libraries to study because they think they have a more reflective and calm environment.

Universities must inform students about information sources at their disposal and the best way of using them.

3. Conclusions

The possibility students have to plan and carry out research work is a way to developing different capacities. They have the opportunity of applying the acquired knowledge but also of confronting themselves with their difficulties. Normally the themes of their research work are freely chosen by them making it possible to serve their interests providing that they are related with Information Science questions and analyzed by scientific methods of research. Those are also moments of creativity and team work implying task division and, most of the times, direct contact with situations of the real world and with people (the respondents) either they are other students or professionals particularly those working in the area of Information Science in libraries or other kind of Institutions or even in a company.

Students are encouraged to do rigorous work in order to present it in international Science encounters. This is a way of challenging them and of making them follow the norms of doing research and writing scientific reports but it is also a moment of learning and confronting themselves with their strong and weak abilities.

In their future professional settings many will be the times where assessing users preferences, needs or satisfaction will be necessary to better plan manage and evaluate their performance or, for instance, the impact of new technologies in people's lives. Being capable of organizing a research to answer some of these questions is an important outcome of their professional education.

These kinds of teaching and learning activities are important tools in any area of knowledge particularly in disciplines that have a practical component that can be applied in the future.

References

- Bonwell, C. & Eison, J. (1991). *Active Learning: Creating Excitement in the Classroom*. AEHE-ERIC Higher Education Report No.1. Washington, D.C.: Jossey-Bass.
- Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review* 31 (1): 21–32.
- De Bruyne, P., Herman, J., & De Schoutheete, M. (1974). *Dynamique de la recherche en sciences sociales. Les pôles de la pratique méthodologique*. Paris: PUF.
- Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist* 59 (1): 14–19.
- Ribeiro, F. (2005). Formação em mercado de trabalho em informação e documentação em Portugal. Salamanca: *VI Coloquio Internacional de Ciencias de la Documentación*.
- Ribeiro, F., & de Pinto, M. M. G. (2009). *IFLA SET Bulletin: IFLA Section on Education & Training*, IFLA, Volume 10, Issue 1, 6-11.
- Silva, A. M., & Ribeiro, F. (2009). Perspectivar a avaliação como operação metodológica no âmbito da Ciência da Informação. Valencia: *IX CONGRESO ISKO-ESPAÑA - Nuevas perspectivas para la difusión y organización del conocimiento*, Universitat Politècnica de Valencia, Volume 1, 246-261.
- Silva, A., Selas, M., Peixoto, J., Graça, R., & Martins, F. (2009). *The use and implementation of electronic resources in the FLUP Library*, Porto: BOBCATSSS. <http://www.bobcatsss2009.org/programme/abstracts.html#posters1>
- Miranda, A., Capitão, G., Moreira, F., Vaz, F., Freitas, H., Correia, J., & Martins, F. (2009). *Preferred information sources: first year university students*. Porto: BOBCATSSS. <http://www.bobcatsss2009.org/programme/abstracts.html#posters1>
- (1) This study resulted in a poster that was presented at the BOBCATSSS Conference – Porto, Portugal, 28-30 January 2009.
- (2) This study resulted in a poster that was presented at the BOBCATSSS Conference – Porto, Portugal, 28-30 January 2009.

A Glance at the Characteristics of Mixed Methods and Importance of its Applications in LIS Researches

Hossein Pashaeizad

Department of Library and Information Science, University of Tehran and Payame Noor University, Iran, E-mail: Pashaeizad@pnu.ac.ir; Pashaeizad@gmail.com

Abstract: Mixed methods research is becoming increasingly articulated, attached to research practice, and recognized as the third major research approach or research paradigm, along with qualitative research and quantitative research. Inquiry and investigation about problems of an interdisciplinary and multidisciplinary domain, such as library and information science studies require decision to be taken about an appropriate research design. In making such a decision, the researcher must tacitly assume a philosophical point of view or a research paradigm. There are four research paradigms which construct the basis of the selection of research methodology and research methods designs. These paradigms include: a) positivism, b) interpretivism, c) critical theory, and d) post-structuralism (Bazargan, 2007). Positivism is the basis of quantitative research method, and of the qualitative research methods are the three paradigms mentioned above (namely; interpretivism, critical theory, and post-structuralism). Because of the nature and complexity

of problems in library and information science settings and also the newly matters evolved in this multidisciplinary field, such as information technologies, digital libraries and so on, neither of the quantitative nor qualitative research methods, alone, are able to investigate problems pertaining to them thoroughly. Therefore, researchers of this domain require have a shift toward applying a combination of quantitative and qualitative research methods designs that is named mixed methods research. In this article, first of all we concisely review the philosophical point of views (paradigms) which construct the basis of research methods. Thereafter history and the characteristics of mixed methods research will be reviewed. Finally, applications of mixed methods research in the library and information science (LIS) are discussed.

Keywords: Mixed methods; Mixed methods research; Paradigms; Qualitative research; Quantitative research; Library science; Library and information science.

1. Introduction

Research by library and information science (LIS) practitioners is needed to create new knowledge and thereby contribute to the growth of LIS as a profession or discipline. It is needed to improve problem solving and decision making in the workplace, to make professional practitioners critical consumers of the research literature, and to better equip librarians to provide optimal information services to researchers in other fields. Reading and conducting research can contribute to career advancement for librarians. It can also improve an individual's ability to think critically and analytically, improve staff morale, and enhance the library's status within its community (Powell, 1997). There are so many definitions of research that is not easy to choose one. Basically, research is an inquiry process that includes the components for collective inquiry, research design, methodology, data collection and analysis, concluding with the communication of the findings. It later appears in a published form. The research process is not the same in all scientific fields. In the social sciences, research is more problem-oriented and may not be aimed at developing cumulative theory. It might fulfill other functions, such as description or evaluation. Library and information science (LIS) has emerged, not only as a profession and the educational program that supports it, but also as a research discipline. Research is needed to create new knowledge and thereby contribute to the growth of LIS as a profession or discipline. If research is absent, non-existent or even scarce, there is no profession, but only an occupation grounded in techniques, routine and common sense. This is, of course, the important reason why research is conducted into LIS (Juznic and Urbanija, 2003).

LIS is known as a multidisciplinary and interdisciplinary scientific field. According to Holland (2008), Information science has incorporated a number of distinct disciplines, including library science, information technology, sociology, communications, computer science, AI into its mainstream and peripheral research. Collaboration is being promoted within many disciplines as a source of innovation and theory progression, including information science (Borgman, 2004; cited in Holland, 2008). Interdisciplinary studies may be defined as a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession. The key defining feature of interdisciplinarity is integration of disciplinary methods and

arguments, as captured in the following definition:

“Interdisciplinary research requires integration of knowledge and/or methods from the various disciplines brought together to address an issue or problem”

Multidisciplinary work refers to the simple juxtaposition of two or more disciplines, focused on the proximity of the disciplines rather than the transformative effort to produce new forms of knowledge (Moran, 2002; cited in Holland, 2008). Possible collaborative efforts between LIS and a variety of disciplines would prove useful to explore. For example, philosophy can provide numerous relevant arguments concerned with the nature of knowledge that could deeply integrate into LIS. Likewise sociology presents theories of considerable interest to LIS research that delves into group dynamics and cultural trends for information use. Cognitive science is another discipline that has much to offer based on its strong collaborative nature. LIS has involved cognitive science in research and theories in varying degrees for a significant period of its history. Birger Hjørland provides an account of the history of cognitive science in LIS and finds strong evidence of collaboration at least from 1977 onwards (Hjørland, 2002). Given that information science has relationships with multiple disciplines at work, its research problems may be complex and multifaceted. LIS researchers need a large toolkit of methods and designs to address complex, multidisciplinary and interdisciplinary research problems. These researchers may be part of a team of researchers with individuals bringing to the table different research skills and training—most likely skills in both quantitative and qualitative research (Creswell & Plano Clark, 2007). These skills are needed to study the increasingly complex problems facing LIS scientists.

2. Research paradigms

A paradigm is a perspective based on a set of assumptions, concepts, and values that are held and practiced by a community of researchers (Johnson and Christensen, 2008). From the 1960s the word paradigm has referred to thought pattern in any scientific discipline or other epistemological context. The Merriam-Webster Online dictionary defines this usage as “a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated; broadly : a philosophical or theoretical framework of any kind” (Wikipedia, 2008). Bryman defines paradigm as a ‘cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done, how results should be interpreted, and so on’ (Bryman, 1988; cited in Barron, 2006). Thomas Kuhn gave the word paradigm its contemporary meaning when he adopted it to refer to the set of practices that define a scientific discipline during a particular period of time. As Kuhn (1970) declares, “there is no such thing as research in the absence of a paradigm” (p. 79). Kuhn himself came to prefer the terms exemplar and normal science, which have more exact philosophical meanings. However, in his book **The Structure of Scientific Revolutions** Kuhn (1970) defines a scientific paradigm as:

- what is to be observed and scrutinized
- the kind of questions that are supposed to be asked and probed for

answers in relation to this subject

- how these questions are to be structured
- how the results of scientific investigations should be interpreted

Kuhn's elaboration of the function of paradigms helps us to understand how normal research can take place with the confidence that results will be cogent and not a random gathering of facts. A paradigm is:

Like an accepted judicial decision in common law, it is an object for further articulation and specification under new or more stringent conditions. To see how this can be so, we must recognize how very limited in both scope and precision a paradigm can be at the time of its first appearance. Paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute. (Kuhn, 1970, p. 23)

Kuhn's argument is that researchers who share a commitment to a particular paradigm are committed to the same rules and standards for scientific practice. His approach has been influential within the social sciences within which two broad research paradigms are often identified – the quantitative and the qualitative. Each paradigm rests upon distinctive foundations and applies a specific approach to researching the social world. For instance, quantitative research is a research strategy that emphasizes measurement in the collection and analysis of data. The quantitative approach is underpinned by a distinctive epistemological and ontological nature.

For the most of the 20th century the quantitative paradigm was dominant (Johnson and Christensen (2008). The epistemological basis for quantitative research is typically, but not exclusively, characterized as positivist. Positivism advocates the application of the methods of the natural sciences to the study of social reality. The general principles of the positivist paradigm are that only phenomena, and therefore knowledge, confirmed by the senses can genuinely be warranted as knowledge; that the function of theory models is to generate hypotheses that can be tested and that will allow explanations of law to be considered. Ultimately, according to the positivist school, the scientific study of society must be undertaken in a manner that is value free that is predicated upon an objective study of the social world. The positivist approach rests upon an epistemological foundation, which emphasizes the principles of measurement, causality, generalization and replication. These theoretical underpinnings therefore presume a certain category of research methods, which are conducive to an objective, positivistic approach such as surveys, questionnaires, structured interviews, experiments, quasi-experiments and official statistics, and content analysis of documents.

The second dominant research paradigm is qualitative research. During the 1980s, the qualitative paradigm came of age as an alternative to the quantitative paradigm, and it was often conceptualized as the polar opposite of quantitative research (Johnson and Christensen (2008). The qualitative research strategy differs markedly from the quantitative approach and is underpinned by very different epistemological and ontological foundations. This approach emphasize the need to understand society as social actors perceive and interpret it, and interpretations of

social phenomena can vary markedly according to the standpoint of the social actor. In light of such an epistemological grounding, qualitative researchers do not typically seek objective appraisal of social phenomena, therefore the arsenal of research methods utilized differs from the quantitative tradition and includes participant observation, unstructured/ semi-structured interviews, focus groups, case studies, ethnographic research and discourse analysis (Barron, 2006).

The difference between quantitative and qualitative research is often seen as quite fundamental, leading people to talk about ‘paradigm wars’ in which quantitative and qualitative research are seen as quarrelsome and incompatible factions. Many researchers define themselves as either quantitative or qualitative. This idea is linked to what are seen as the different underlying philosophies and worldviews of researchers in the two ‘paradigms’ (also called ‘epistemologies’). According to this view, two fundamentally different worldviews underlie quantitative and qualitative research. The quantitative view is described as being ‘realist’ or sometimes ‘positivist’, while the worldview underlying qualitative research is viewed as being ‘subjectivist’. Realists take the view that what research does is uncover an existing reality. ‘The truth is out there’ and it is the job of the researcher to use objective research methods to uncover that truth. This means that the researcher needs to be as detached from the research as possible, and use methods that maximize objectivity and minimize the involvement of the researcher in the research. This is best done using methods taken largely from the natural sciences (e.g. biology, physics, etc.), which are then transposed to social research settings. Positivism is the most extreme form of this worldview. According to positivism, the world works according to fixed laws of cause and effect. Scientific thinking is used to test theories about these laws, and either reject or provisionally accept them. In this way, we will finally get to understand the truth about how the world works (Muijs,2004).

A lot of researchers, both quantitative and qualitative, take a pragmatist approach to research, using different methods depending on the research question they are trying to answer. In some cases this will lead them to quantitative research, for example when they need to give a quantitative answer to a question or generalize findings to a population, or are looking to test a theory mathematically; in other cases they will employ qualitative methods. Sometimes a mixed methods approach combining quantitative and qualitative methods will be the most appropriate. Although the modern roots of mixed research go back to the late 1950s (and its historical roots go much further back in time), some researchers think that mixed research truly became the legitimate third paradigm with the publication of the **Handbook of Mixed Methods in Social and Behavioral Research** (2003) by Tashakkori and Teddlie. At the same time, mixed research has been conducted by practicing researchers throughout the history of research (Johnson and Christensen, 2008). Different schools of thought have presented in figure 1.

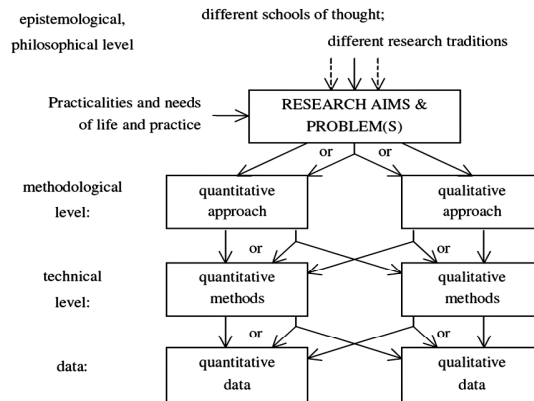


Figure 1. The levels of research in practice (adapted from Niglas 1999)

3. Mixed methods research

Since the 1960s, an increasing number of researchers in various fields of social and behavioral sciences have been advocating the combining of quantitative and qualitative approaches to the study of various social phenomena (Creswell & Plano Clark, 2007; Tashakkori & Teddlie, 2003). The combining of qualitative and quantitative approaches is most commonly known as mixed methods research. As noted by Johnson and Onwuegbuzie (cited in Collins, Onwuegbuzie & Jiao, 2007) mixed methods research is formally defined as the class of research where the researcher mixes or combines quantitative and qualitative research techniques into a single study. Mixed methods research is the processes and procedures for collecting, analyzing and inferring both quantitative and qualitative data in a single study or in sequential studies, based on priority and sequence of information (Tashakkori & Teddlie, 1998; Creswell & Plano Clark, 2007). Mixed methods is an approach to inquiry in which the researcher links, in some way (e.g. merges, integrates, connects), both quantitative and qualitative data to provide a unified understanding of a research problem (Creswell & Plano Clark, 2007). Teddlie & Tashakkori (2003) define truly mixed approach methodology as a methodology that incorporates multiple approaches in all stages of research from problem identification to research questions, data collection, data analysis, and final inference; and includes a transformation of the data and their analyses through the other approach (i.e. quantification and qualitzation of data).

Creswell and Garrett (2008) point out that mixed methods research has come into its own as a research approach in the last 20 years. To understand the beginnings of mixed methods, we need to return to the 1980s. Prior to this decade, authors wrote about the importance of gathering both quantitative and qualitative data and debated the merits of combining qualitative and quantitative data. These early writers had not conceptualized mixed methods as a distinct approach to inquiry. Several writers working independently in different parts of the world conceptualized mixed methods as we know it today. Tashakkori and Teddlie (2003) argue that mixed methods designs evolved from the notion of ‘triangulating’ the information from different data sources. However, mixed

methodology evolved as a “third methodological movement” originated from the “paradigm wars,” in which each camp was criticizing the other’s methods of study, rigor of its procedures and the validity of its outcomes. There are some essential theoretical assumptions that should be taken into consideration and adhered to when conducting a mixed methods study. These are the pragmatist philosophy, compatibility thesis and fundamental principle of mixed methods research (Teddlie & Tashakkori, 2003; Creswell & Plano Clark, 2007). The pragmatist philosophy keeps the researchers away from pointless philosophical arguments and enables them to mix the research components in the way they believe to work for the given research problem and context. This is also consistent with the fundamental principle of mixed methods research, since this principle expresses that the “methods should be mixed in a way that has complementary strengths and nonoverlapping weaknesses” (Johnson & Turner, 2003; Creswell & Plano Clark, 2007). Lastly, as for the compatibility thesis which refers to the assumption that quantitative and qualitative methods are compatible and can be mixed (Teddlie & Tashakkori, 2003; Creswell & Plano Clark, 2007). It would be impossible for any researcher to even propose such a study, if this thesis were not assumed. In addition to the above mentioned fundamental assumptions, Creswell, et al. (2003) state four additional assumptions or criteria implicit in the design of the studies:

1. Implementation of data collection referring to the sequence in which the researcher collects qualitative and quantitative data, which also affects data analysis and written report. Both qualitative and quantitative data collection might occur either concurrently or sequentially. This implementation approach also raises an issue of iterative cycles, where researcher may go back and forth between qualitative and quantitative data collection. In addition to the sequencing, researchers can also mix different qualitative and quantitative data collection techniques by utilizing intra- or inter-method mixing. Intra-method mixing is defined as concurrent or sequential use of a single method, e.g. using both open- and close-ended items in a questionnaire, whereas inter-method mixing utilizes two or more methods concurrently or sequentially, e.g. using questionnaires and interviewing. These two different kinds of method mixing are also called “data triangulation” and “method triangulation” respectively.
2. Priority refers to which method, either quantitative or qualitative or both, is given more priority, weight and attention in the study.
3. Stage of integration, which stands for the phase in the research process where the mixing or connecting of the quantitative and qualitative data occurs. It might occur in different phases of the study, e.g. problem description, research questions, research methods, data collection and analysis, and inference processes.
4. Theoretical perspectives refer to researchers’ personal stances toward the topics they are studying based on their personal history, gender, experience, culture and class.

Based on these criteria Creswell et al (2003) specify six different types of major mixed methods research: sequential explanatory, sequential exploratory, sequential transformative, concurrent triangulation, concurrent nested, and concurrent transformative.

Philosophically, mixed methods research is the “third wave” or a third research

movement, a movement that moves past the recent paradigm wars by offering a logical and practical alternative. Philosophically, mixed research makes use of the pragmatic method and system of philosophy. Its logic of inquiry includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results). The past decade has seen a proliferation in the number of mixed methods studies undertaken. The popularization of mixed methods research has led to an increase in the number of publications devoted to methodological issues in this field-the most comprehensive of which, to date, has been the Handbook of Mixed Methods in Social & Behavioral Research (Tashakkori & Teddlie, 2003), which has provided researchers with some theoretical and practical tools for conducting mixed methods research. Nevertheless, as noted by Teddlie and Tashakkori (2003), six unresolved issues and controversies in the use of mixed methods in the social and behavioral sciences still prevail, namely, (a) the nomenclature and basic definitions used in mixed methods research, (b) the utility of mixed methods research, (c) the paradigmatic underpinning for mixed methods research, (d) design issues in mixed methods research, (e) issues in making inferences in mixed methods research, and (f) the logistics of conducting mixed methods research. Moreover, Onwuegbuzie (2007) has identified the following four crises or challenges that researchers face when undertaking mixed methods research: representation, legitimation, integration, and politics.

In addition to triangulation, the third methodological movement has been given many names such as blended research, integrative research, multimethod research multiple methods, triangulated studies, ethnographic residual analysis, and mixed research. An advantage of the broader term mixed research, is that it does not suggest a limitation of mixing to methods only. Mixed methods research has become the most popular term used to describe this movement. It is important to keep in one's mind, however, that the word methods should be viewed broadly. Some researchers believe that a broad interpretation and use of the word methods (in mixed methods) allows inclusion of issues and strategies surrounding methods of data collection (e.g., questionnaires, interviews, observations), methods of research (e.g., experiments, ethnography), and related philosophical issues (e.g., ontology, epistemology, axiology). Others believe each of the three major approaches to research include assumptions, principles, and values about these kinds of methodology and practice-related issues as parts of the research paradigm (Johnson, Onwuegbuzie & Turner, L.A.(2007).

Mixed methods can be used to enhance our understanding of a topic typically studied from just a qualitative or quantitative perspective. Alongside social scientists' increasing shift toward thinking that qualitative and quantitative orientations are complementary rather than competing perspectives, there has been interest in developing strategies to combine qualitative and quantitative data collection and analytical approaches. Researchers can consider both causal (quantitative) and interpretive (qualitative) questions when designing their research projects (Kalof, Dan and Dietz, 2008).

A number of factors have contributed to the evolution of mixed methods research.

The complexity of our research problems calls for answers beyond simple numbers in a quantitative sense or words in a qualitative sense. A combination of both forms of data can provide the most complete analysis of problems. Researchers can situate numbers in the contexts and words of participants, and they can frame the words of participants with numbers, trends, and statistical results. Both forms of data are necessary today. In addition, qualitative research has evolved to a point where writers consider it a legitimate form of inquiry in the social and human sciences. Quantitative researchers, we believe, recognize that qualitative data can play an important role in quantitative research. Qualitative researchers, in turn, realize that reporting only qualitative participant views of a few individuals may not permit generalizing the findings to many individuals. Audiences such as policy makers, practitioners, and others in applied areas need multiple forms of evidence to document and inform the research problems. A call for increased sophistication of evidence leads to a collection of both quantitative and qualitative data. In recent years, many authors have begun to advocate for mixed methods research as a separate methodology or design. Tashakkori and Teddlie (2003) called mixed methods research the “third methodological movement”. This means that in the evolution of research methodologies, mixed methods now follows quantitative approaches and then qualitative approaches as the third movement. Unquestionably, many scholars are interested in mixed methods research as it has evolved during the last few decades (Creswell, 2008).

4. Challenges in mixed methods research

Some researchers (for example; Collins, K.; Onwuegbuzie, A. J. and Jiao, Q. G., 2007) have mentioned four challenge including challenge of representation, challenge of legitimation or validity, challenge of integration, and challenge of politics for mixed methods research. The challenge of representation refers to the fact that sampling problems characterize both quantitative and qualitative research. With respect to quantitative research, the majority of studies utilize sample sizes that are too small to detect statistically significant differences or relationships and utilize nonrandom samples that prevent effect-size estimates from being generalized to the underlying population. In qualitative research, the challenge of representation refers to the difficulties researchers encounter in capturing lived experiences via their social texts. In mixed methods research, the challenge of representation often is intensified because both the qualitative and quantitative components of studies bring to the study their own unique challenges. In mixed methods studies, the challenge of representation refers to the difficulty in capturing (i.e., representing) the lived experience using text in general and words and numbers in particular.

The second challenge in mixed methods research pertains to legitimation or validity. With respect to quantitative research, the importance of legitimation, or what is more commonly referred to as “validity,” has been long acknowledged and is well documented in the literature, including measurement-related validity (e.g., construct-related validity, criterion-related validity, content-related validity) and design-related validity (e.g., internal validity, external validity). With respect to the qualitative research paradigm, the issue of legitimation has been more

controversial. As is the case for the challenge of representation, the challenge of legitimation is greater in mixed methods studies than in monomethod studies (i.e., quantitative research or qualitative alone). The challenge of legitimation refers to the difficulty in obtaining findings and/or making inferences that are credible, trustworthy, dependable, transferable, and/or confirmable.

The third challenge in mixed methods research pertains to integration. This challenge compels mixed methods researchers to ask questions such as the following: Is it appropriate to triangulate, expand, compare, or consolidate quantitative data originating from a large, random sample with qualitative data arising from a small, purposive sample? How much weight should researchers and/or consumers place on qualitative data compared to quantitative data?

The fourth challenge in mixed methods research is the challenge of politics. This challenge refers to the tensions that come to the fore as a result of combining qualitative and quantitative approaches. These tensions include any conflicts that occur when different investigators are used for the qualitative and quantitative components of an investigation, as well as the contradictions and paradoxes that come to the fore when qualitative and quantitative data are compared and contrasted. The challenge of politics also pertains to the difficulty in persuading the consumers of mixed methods research, including stakeholders and policy makers, to value the findings stemming from both the qualitative and quantitative phases of a study.

5. Applications of mixed methods research in LIS

As mentioned in production section of this article, LIS as an multidisciplinary field have interaction with many disciplines such as psychology, linguistics, information technology, computer science, communications, sociology and so on..., therefore need to use proper research methods, especially mixed method, for facing with and studying of the problems evolving from those disciplines. For a long time, the quantitative and qualitative research paradigms were dominant and prevalent in social science researches (Bowler & Large, 2008). With the research issues and problems being more complex in social science, none of those research methods are not able to solve the newfangled multifaceted research problems in a multidisciplinary areas such as LIS anymore, so needs to use the new research methods designs and approaches for study of the those problems came out. Although mixed methods research has been used in various disciplines (for example sociology, education, nursing, anthropology, management, social policy, healthcare, and psychology), there are not sufficient evidences about using that in library and information science to date. The status of mixed methods research in LIS can be revealed through examining books and articles about research methods in LIS and by analyzing published research reports. For finding how did this approach shape research in LIS, Fidel (2008) conducted an analysis of 465 articles published in four major LIS research journals. Findings of study revealed that 22 articles (5%) employed mixed methods research. However the recognition of mixed method research by name or as a research method was absent from these articles and from the methodological literature in LIS. Therefore he concluded that mixed methods research is not common in library and information science (LIS)

and has not been discussed in its literature. He adds the various strengths of mixed methods research suggest that being cognizant of its possible use in LIS would benefit researchers in the field. Findings of Fidel's study revealed that the term mixed methods is missing from most methodological Books.

To LIS researchers, the most familiar form of mixed methods research use is triangulation, one of the methods to test the validity and accuracy of a study. Triangulation is employed primarily in qualitative research. However, not all triangulations require the use of mixed methods research. For example, Patton (2002, cited in Fidel, 2008) identified four types of triangulation:

1. Methods triangulation: Checking the consistency of findings generated by different data collection methods
2. Triangulation of sources: Checking the consistency of different data sources within the same method
3. Analyst triangulation: Using multiple analysts to review findings
4. Theory/perspective triangulation: Using multiple perspectives or theories to interpret the data

LIS researchers can use mixed methods research when no single approach can fully investigate the phenomenon, particularly when the phenomenon is complex and multifaceted. Another case is when qualitative, exploratory investigation generates hypotheses to be tested. Hypotheses generated this way add depth to the evidence available for testing them. Eventually, using mixed methods research allows LIS researchers to address issues more widely and more completely than one method could, which in turn amplifies the richness and complexity of the research findings. For example, you can suppose a researcher is interested in understanding the Web searching behavior of under graduate students. For that purpose he can develop and test a few hypotheses about the association between variables describing the student population (independent variables) and those illustrating web searching behavior (dependent variables). He can collect data through a multiple-choice questionnaire that he administers to students. To make sure that the sample is representative of all students, he needs to know how to stratify the population before administering the questionnaire. To answer this question, he observes class and Web searching sessions, and conduct open-ended interviews with several students to explore their perception of the differences among students. This qualitative investigation provided additional useful information. At its conclusion, researcher may re-considers his study design after than he discovered that teachers were important players in shaping students' searching behavior. He may decide to include them in the investigation. Researcher can use this qualitative analysis to enhance data collection as well. Through his interactions with the participating students he will create rapport with the potential respondents to the questionnaire; this will help him achieve a satisfying response rate.

An example of mixed methods research use in study is Web searching behavior of elementary school students. Researcher, however, prefers to explore it to provide a thick description of the process. For that purpose, she collects data through observation and open-ended interviews. To support her study design and data collection, she initially administers a simple questionnaire to the student

population from which she would draw her qualitative sample. The data collected from the questionnaires will help her to improve the study in several ways. Through them she creates a profile of the population which guides her sampling. This was particularly important because she has planned to employ purposeful sampling. To select the participants, she needs information about individuals that will be collected only from the students themselves—such as their searching experience or whether they have Internet connection at home. In addition, the questionnaires provide background information about each participant that she takes into consideration when she conducts the observation and interviews with individual students—such as the student's first language or favorite topic. Analyzing the qualitative data, she may discover some prominent themes in the students' searching behavior. She thinks these are important findings but she can not generalize them because she draws the participants from a relatively small sample of students in only one school. To generalize the findings, she administers questionnaire to a diverse population. The data collected this way also may verify her interpretation of the qualitative results.

6. Conclusion

Today's research world is becoming increasingly interdisciplinary, complex, and dynamic; therefore, many researchers need to complement one method with another, and all researchers need a solid understanding of multiple methods used by other scholars to facilitate communication, to promote collaboration and to provide superior research. Taking a non-purist or compatibilist or mixed position allows researchers to mix and match design components that offer the best chance of answering their specific research questions. Because no single research method can tap all dimensions of a complex research problem, it is often valuable to combine two or more methods, drawing conclusions from a synthesis of the results. Multiple method use, also called triangulation, unquestionably results in a broader perspective on the problem and often more persuasive findings for policymakers. Similar results from two or more methods could increase the credibility of the findings, whereas dissimilar results might raise new questions about alternative interpretations. Awareness of mixed methods research among LIS researchers can be increased through various channels. When authors who employ the approach explain their motivation for its use- along with its advantages and challenges and the mixing procedures they followed-readers enrich their understanding of these issues and may be exposed to new ways of thinking about the approach and its implementation.

Mixed methods research also is an attempt to legitimate the use of multiple approaches in answering research questions, rather than restricting or constraining researchers' choices (i.e., it rejects dogmatism). It is an expansive and creative form of research, not a limiting form of research. It is inclusive, pluralistic, and complementary, and it suggests that researchers take an eclectic approach to method selection and the thinking about and conduct of research. What is most fundamental is the research question- research methods should follow research questions in a way that offers the best chance to obtain useful answers. Many research questions and combinations of questions are best and most fully answered through mixed research solutions.

Mixed methods designs hold a great deal of promise for the researcher who wants to tackle complex issues that reside at multiple levels- the individual as well as the social. It can enhance the type of information gathered and can serve to increase the validity of both qualitative and quantitative projects. There is the idea that by using both approaches can bring out the best in both methods (increasing the validity of a given study through triangulation, for example), while offsetting the weaknesses of the other. The idea, as we have noted earlier, is that “The Whole is greater than the sum of its parts”. However, having said this, there are a range of caveats from the conceptual to the practical that one must consider when using mixed methods designs. Mixed methods blur the line between research paradigms, and it is unclear how concerned researchers should be about this. There are those “pragmatists” who advocate for whatever methods work, sometimes with little regard for issues of epistemology and methodology, while others, known as “purists”, see such boundary crossings as violating the very foundations of scientific thought. Many others take positions between these views on what we see as a continuum of opinions on matter. Mixed methods is not a panacea; a magic elixir that one pours onto a research project to make it work. Mixed methods are techniques for getting as knowledge building. More is not necessarily better; the sum may not be greater than its parts.

References

- Bazargan, A. (2007). “Mixed methods design: A preferable approach in educational inquires”, *Journal of Psychology and Education*, Vol. 37, No.3, 101-119.
- Barron, L. (2006). “Paradigm” in *The Sage Dictionary of Social Research Methods*, Compiled and edited by Victor Jupp, London: Sage, 212-213.
- Borgman, C. (2004), *E-Science, Digital Libraries and Knowledge Communities*, Oxford Internet Institute, Oxford.
- Bowler, L. and Large, A. (2008). Design-based research for LIS, *Library & Information Science Research* Vol. 30, No. 1, 39-46.
- Collins, K.; Onwuegbuzie, A. J. & Jiao, Q. G. (2007). A Mixed Methods Investigation of Mixed Methods Sampling Designs in Social and Health Science Research, *Journal of Mixed Methods Research*, Vol.1, No.3, 267-294.
- Creswell, J.W. (2008). “Mixed methods research” in *The Sage Encyclopedia of Qualitative Research Methods*, LISA M. GIVEN (Ed.), London: Sage, 526-529.
- Creswell, J.W. (ed.) (2008). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Thousand Oaks, CA: Sage.
- Creswell, J.W. & Garrett, A. L. (2008). The “movement” of mixed methods research and the role of educators, *South African Journal of Education*, Vol. 28, 321-333
- Creswell, J.W & Plano Clark, V.L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.
- Fidel, R. (2008). Are we there yet? : Mixed methods research in library and information science, *Library & Information Science Research* 30, 265–272.
- Hjørland, B. (2002), "Epistemology and the socio-cognitive perspective in information science", *Journal of the American Society for Information Science and Technology*, Vol. 53 No.4, 257-70.
- Holland, G. A. (2008). Information science: an interdisciplinary effort? *Journal of Documentation*, Vol.64, no.1, 7-23.
- Johnson, B. & Christensen, L. (2008). *Educational Research: Quantitative, Qualitative, and Mixed Approaches*, Thousand Oaks, CA. : Sage.

- Johnson, B.; Onwuegbuzie, A.J. & Turner, L.A.(2007). Toward a Definition of Mixed Methods Research, *Journal of Mixed Methods Research*, 1, 112-133.
- Juznic, P. & Urbanija, J.(2003). Developing research skills in library and information science studies, *Library Management*, Vol. 24, No. 6/7, 324-331.
- Kalof, L.; Dan, A. & Dietz, T. (2008). *Essentials of Social Research*, London: McGraw-Hill.
- Kuhn, T. S. (1970). *The structure of scientific revolutions* (2d ed.). Chicago: University of Chicago Press.
- Kwon,N.(2008). A Mixed-Methods Investigation of the Relationship between Critical Thinking and Library Anxiety among Undergraduate Students in their Information Search process, *College & Research Libraries*, March- Vol. 69, No.2, 117-131.
- Moran, J. (2002), *Interdisciplinarity*, Routledge, London.
- Talja, S., Tuominen, K., Savolainen, R. (2005), "'Isms' in information science: constructivism, collectivism and constructionism", *Journal of Documentation*, Vol. 61 No.1, pp.79.
- Muijs,D. (2004) *Doing Quantitative Research in Education with SPSS*,London: Sage.
- Niglas, K. (1999). Quantitative and Qualitative Inquiry in Educational Research: is there a paradigmatic difference between them? Paper given at ECER99, Lahti, 22–25. September 1999; Education Line <http://www.leeds.ac.uk/educol/documents/00001487.htm>
- Onwuegbuzie, A. J. (2007). Mixed methods research in sociology and beyond. In G. Ritzer (Ed.), *The Blackwell encyclopedia of sociology*, Oxford, UK: Blackwell.
- Powell, R.R. (1996). Recent Trends in Research: A Methodological Essay, *Library Research Seminar I*, Florida State University, Tallahassee, November 1-2
- Powell,R.R.; Baker, L.M. & Mika, J.J.(2002). Library and information science practitioners and research, *Library & Information Science Research*, 24, 49–72.
- Tashakkori, A. & Teddlie, C. (Eds.). (2003). *Handbook of Mixed Methods in the Social and Behavioral Science*. Thousand Oaks, CA: Sage.
- Tashakkori, A. & Creswell, J.W. (2007). The new era of mixed methods, *Journal of Mixed Methods Research*, 1, 3-7.
- Tashakkori A. & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.
- Todd, Z. et. al. (eds.) (2004). *Mixing Methods in Psychology : The integration of qualitative and quantitative methods in theory and practice*, East Sussex: Psychology Press.
- Wikipedia (2008). "Paradim", <http://en.wikipedia.org/wiki/Paradigm>

Bibliometric Analyses on Repository Contents for the Evaluation of Research at Wageningen UR

**Marco G. P. van Veller, Wouter Gerritsma, Peter L. van der Togt,
Charles D. Leon and Corrie M. van Zeist**

Wageningen UR Library, PO Box 9100, 6700 HA Wageningen, The Netherlands

Abstract: Since the last two decades, Wageningen UR Library has been involved in bibliometric analyses for the evaluation of scientific output of staff, chair groups and research institutes of Wageningen UR. In these advanced bibliometric analyses several indicator scores, such as the number of publications, number of citations and citation impacts, are calculated. For a fair comparison of scientific output from staff, chair groups or research institutes (that each work in a different scientific discipline with specific publication and

citation habits) scores of the measured bibliometric indicators are normalized against average trend (or baseline) scores per research field. For the collection of scientific output that is subjected to the bibliometric analyses the repository Wageningen Yield (WaY) is used. This repository is filled from the research registration system Metis in which meta data for scientific output is registered by the secretaries of the research groups of Wageningen UR. By the application of a connection between the meta data of publications in WaY and citation scores in Thomson Reuters' Web of Science, custom-made analyses on the scientific output and citation impact of specific entities from Wageningen UR can be performed fast and efficiently. Moreover, a timely registration of new scientific output is stimulated (to ensure their inclusion in future bibliometric analyses) and the quality of meta data in WaY is checked by the library staff and research staff from the research entities under investigation, thus promoting communication between the library and customers.

Keywords: Bibliometric analysis; Citation impact; Repository; Research evaluation; Library.

1. Introduction

One of the main activities of doing scientific research involves the publication on this research in scientific literature. It is for this reason that measurement of scientific output and impact of scientific publications may be used to estimate the productiveness and importance of the underlying research activities. Both productiveness and importance of research are essential criteria for making decisions regarding further development of research at institutes or universities. Therefore, policy makers and boards of these research organizations are interested in quantitative measurements on the output and impact of scientific publications for monitoring and evaluation purposes.

Since the last two decennia, the library of Wageningen University and Research (or Wageningen UR) has been involved in various quantitative analyses on scientific publications produced by staff of the university and institutes. These advanced bibliometric analyses were performed for various periods of time on scientific output of staff, chair groups and research institutes (or entities) of Wageningen UR.

Originally, the scientific output, on which the bibliometric analyses were performed, was selected by doing a retrospective search in citation enhanced bibliographical databases for the Wageningen UR entities under consideration. Thereby it was very important to be as complete as possible in the retrospective search in order to select all scientific output on which the analyses should be based. For this reason, the results from the retrospective search were checked by the Wageningen UR entities for which the bibliometric analysis was performed. Missing publications were added and corrections were made before the scientific output was subjected to the bibliometric analyses.

The additions and corrections on scientific output, however, were not registered and needed to be made for each subsequent bibliometric analysis. It is for this reason that since 2009 the library of Wageningen UR uses the repository Wageningen Yield (WaY) for bibliometric analyses for Wageningen UR entities. This repository contains the meta data of all publications (as well as a link to the full-text of the publication if available) that have been published by the staff and employees from Wageningen UR. For this reason WaY is a very comprehensive

source for the scientific output that is subjected to the bibliometric analyses. This paper discusses the application of the repository in the bibliometric analyses performed by Wageningen UR Library as well as the mutual advantages to both the bibliometric analyses and the repository that results from this combination.

2. Choice of bibliographic databases for bibliometric analyses

The aim of a bibliometric analysis is to obtain a quantitative overview of the scientific output and the impact of citations to this scientific output published by a researcher, research group or research organization. At Wageningen UR bibliometric analyses are made at regular intervals as part of the continuous research evaluation of staff, research groups or institutes. The advanced bibliometric analyses performed by Wageningen UR Library are based upon scientific articles that are published in scholarly journals or serials that are covered by the bibliographic database Web of Science (WoS) from Thomson Reuter Scientific.

In WoS almost 8000 current peer reviewed journals in different scientific disciplines are covered. This selection of journals is considered to include the most important peer reviewed journals for science. In addition to standard bibliographical data, WoS contains for each of the articles (in the covered journals) the number of citations to each article. The latter is updated on a regular basis.

Besides WoS, Thomson Reuters Scientific also produces the database Essential Science Indicators (ESI) which provides the world average number of citations of articles for 22 different research fields. The world averages are updated five times per year and a series of world averages over a certain number of years is called a baseline. Besides world averages, ESI also provides the average number of citations per year for the top 0.01%, 0.1%, 1%, 10%, 20% and 50% most cited articles per research field. In an advanced bibliometric analysis combination of WoS and ESI is essential for the calculation of the impact of citations because citation counts for an article should be obtained from WoS, the baselines follow from ESI and the journals are classified in the research fields in ESI.

3. Normalization of citation impacts

The impact of citations to an article is normalized for one of the 22 different research fields to which the article belongs. Thereby, the research field for an article is determined on basis of the journal in which it has been published and can be found in the ESI. For each article, the citation impact is normalized by benchmarking the number of citations against the world average citation value, obtained for the same year in which the article has been published via the baseline for the research field to which the article belongs. The reason to normalize citation impacts lies in the different publication and citation cultures that apply to different research fields (e.g. the world average number of citations for publications in Molecular biology & Genetics are approximately eight times larger than in Mathematics). It is for this reason that only by normalizing citation impacts, monitoring and evaluation of these impacts over different research fields can be performed.

Normalization of citation impacts of a series of articles (e.g. published by a

particular research group that is subject to a bibliometric analysis) can be done in two alternative ways. Both ways of normalization result in a measure that shows the relation of the impact of the analyzed set of articles to the world average of 1. One normalized measure for the citation impact is obtained by dividing the sum of citations to all considered articles by the sum of the world average citation rates for these articles. This ratio leads to the Citation Impact (CI or Crown Indicator sensu van Raan, 2004) for the series of articles. Alternatively, normalization of citation impacts of a series of articles can also be carried out at the level of individual articles. In this case, a citation impact is calculated for each article separately and normalization is accomplished by calculation of the mean of these impacts. This approach on the level of individual articles leads to a measurement for the citation impact known as the Relative Impact (RI sensu Gerritsma, 2006).

4. Advanced indicators for bibliometric analyses

Besides normalized citation impacts also other indicators result from a bibliometric analysis. In bibliometric analyses at Wageningen UR Library for a series of articles (e.g. for a particular Wageningen UR entity) the following indicators are measured:

- $N = \text{Total number of articles in series that is examined} = \sum_{t=1}^T n_t$
- $C = \text{Total number of citations to the } N \text{ articles} = \sum_{t=1}^T \sum_{i=1}^{n_t} C_{t,i}$
- $\text{CPP} = \text{Average number of citations per article} = \frac{\sum_{t=1}^T \sum_{i=1}^{n_t} C_{t,i}}{N}$
- $\text{CI} = \text{Citation Impact} = \frac{\sum_{t=1}^T \sum_{i=1}^{n_t} C_{t,i}}{\sum_{t=1}^T \sum_{i=1}^{n_t} W_{avg,t,i}}$
- $\text{RI} = \text{Relative Impact} = \frac{\sum_{t=1}^T \sum_{i=1}^{n_t} \frac{C_{t,i}}{W_{avg,t,i}}}{N}$
- $\%T10 = \text{Percentage of the 10\% most cited articles compared to the total number of articles in the series} = \frac{N(C_{t,i} \geq C_{10\%,t,i})}{N} * 100\%$
- $\%T1 = \text{Percentage of the 1\% most cited articles compared to the total number of articles in the series} = \frac{N(C_{t,i} \geq C_{1\%,t,i})}{N} * 100\%$
- $\%NC = \text{Percentage of non-cited articles compared to the total number of}$

$$\text{articles in the series} = \frac{N(C_{t,i} = 0)}{N} * 100\%$$

With

n_t = Number of articles published in year t

$C_{t,i}$ = Number of citations to article i, published in year t

$W_{avg,t,i}$ = World average number of citations for articles in same research field as for article i for the year t in which article i has been published

$C_{10\%,t,i}$ = Average number of citations for 10% best cited articles in same research field as for article i for the year t in which article i has been published

$C_{1\%,t,i}$ = Average number of citations for 1% best cited articles in same research field as for article i for the year t in which article i has been published

Via these eight indicators Wageningen UR Library tries to give an impression of both the scientific productivity (by counting the number of articles published by the Wageningen UR entities) as well as the impact of this output in the form of citations (by calculation of Citation or Relative Impacts of articles published by the Wageningen UR entities).

For the eight advanced bibliometric indicators both the CI and RI are preferred for the measurement of citation impact because they have been normalized to the research field in which the Wageningen UR entity is working. Because of the different way of normalizing citation impacts of articles differences can be found between these two indicators. Hereby, the RI measures citation impact on an individual basis and may be susceptible to outliers due to articles with high citation scores related to their corresponding world averages. The CI, to the contrary, applies normalization to the complete set of articles as a whole and thereby gives a relative larger weight to the number of citations for older articles and articles in highly cited research fields.

Although the CPP is not normalized to a particular research field, it gives (in relation to the CI) an impression on the world average number of citations per article for the most dominant research field in which the Wageningen UR entity has published. In general, the CPP shows an increasing trend with the age of the articles for which the CPP has been calculated. Both the %T10 and %T1 give indications for excellent cited Wageningen UR entities. Finally, high values of %NC weigh down the values of CPP, RI and CI in bibliometric analyses.

5. Repository contents as a source for bibliometric analyses

In order to perform a bibliometric analysis on the scientific output of a particular Wageningen UR entity, first the series of articles for which the eight different indicators will be calculated need to be selected. As indicated above, these articles need to be published in scientific journals or serials that are covered by WoS. By examining these articles only, one is able to obtain the number of citations for each article from WoS and relate it to values of the applicable baseline for normalization.

Besides selection of articles from journals covered by WoS it is important that the series of articles that has been selected is identified as the set of articles published by the Wageningen UR entity that is evaluated over a certain period of time.

Hereby it is important that a complete set of articles is obtained and that no mistakes are made by selection of articles from other persons, groups or institutes than the one(s) that is evaluated. Selection of the right series of articles for a particular Wageningen UR entity is based upon the meta data (such as affiliation information of the authors) of the articles.

Meta data of the scientific output of whole Wageningen UR are collected in a research registration system (called Metis) and made accessible to users via the repository WaY. Registration of new publications in the research registration system is done by the secretaries of the research groups and both the research registration system Metis and the repository WaY are (further) developed and maintained by Wageningen UR Library.

The repository WaY contains besides the meta data also links to scientific output of the Wageningen UR entities. Further, also affiliation data and all work relations of the staff of Wageningen UR with various Wageningen UR entities (and others outside Wageningen UR) and the research theme or graduate school in which the staff member participates is recorded in great detail. The in-house registration and dissemination of meta data of scientific output from Wageningen UR staff enables a more reliable selection of a series of articles for a bibliometric analysis (for a particular Wageningen UR entity) than selection of these articles on the basis of affiliations mentioned in the articles. Also, if the registration of meta data for new scientific output in the repository WaY is complete and timely, the chances of missing articles in a bibliometric analysis are minimized.

6. Connection between the repository and bibliographical database for bibliometric analyses

For a bibliometric analysis of a series of articles (published by a particular Wageningen UR entity) selected from the repository WaY a connection needs to be made between the meta data for the selected articles in the research registration system Metis and the bibliographical information for the same articles in WoS.

By searching in WoS on affiliation Wageningen UR and its various institutes a list of articles from authors that work (or have worked) at Wageningen UR is obtained. The bibliographical records for these articles are matched with records for the articles that are registered in Metis by using information from the Digital Object Identifier, ISSN in combination with volume and page number or title. As a result of this matching for each article in Metis (which can be identified in Metis by a unique article number), its ISI-number is obtained from WoS. The ISI-number is entered in the record for the article in WaY and can be used for identification of the article in WoS. Since the ISI-number of each article is stored in WaY the matching between bibliographical data from Metis with WoS needs to be done for each (added) article only once.

With the meta data in WaY on affiliation and work relations different selections can be made for series of articles published by one (or more) Wageningen UR entity (or entities) that will be subjected to a bibliometric analysis. For a particular selected series of articles ISI-numbers are collected from WaY and used to obtain the number of citations ($C_{t,i}$ in formulas above) per article from WoS. Because this number of citations changes over time it needs to be collected from WoS on a

frequent basis. Besides the number of citations also the world average number of citations ($Wavg_{t,i}$ in formulas above) and the average number of citations for 10% and 1% most cited articles (respectively $C_{10\%,t,i}$ and $C_{1\%,t,i}$ in formulas above) are updated for each research field from ESI frequently.

The values of the bibliometric data $C_{t,i}$, $Wavg_{t,i}$, $C_{10\%,t,i}$ and $C_{1\%,t,i}$ are used to calculate the different indicators that are mentioned in the formulas above. Hereby the research field of an article is obtained by making a connection (on basis of ISSN; obtained from WaY) between the journal in which the article has been published and information obtained from ESI on the classification of journals in the different research fields.

7. Example of a bibliometric analysis for a research group of Wageningen UR

An example of the results from a bibliometric analysis that has been performed for the scientific output of a research group of Wageningen UR is given in the two tables below. Table 1 gives yearly results for the different indicators whereby publications from different research field may have been combined per year. Table 2 is based on the same series of articles from this research group but lists the different indicators per research field whereby publications from different years may have been combined in a research field. From the two tables trends in the scientific output and impact over years can be derived as well as information on the most prominent research fields in which this research group published.

Table 1: Indicators calculated from a bibliometric analysis on 139 articles published by a research group from Wageningen UR in the years 2002-2007.

Year	N	C	CPP	CI	RI	%T10	%T1	%NC
2002	10	527	52.7	3.46	4.92	50%	30%	0%
2003	21	545	26.0	1.54	1.89	33%	5%	0%
2004	25	509	20.4	1.71	2.53	28%	8%	0%
2005	25	323	12.9	1.35	1.83	28%	4%	0%
2006	26	319	12.3	2.52	3.22	38%	15%	8%
2007	32	285	8.9	3.73	4.69	38%	19%	13%
All years	139	2508	18.0	2.01	3.10	35%	12%	4%

Table 2: Indicators calculated from a bibliometric analysis on 139 articles published by a research group from Wageningen UR in five different research fields.

Research Field	N	C	CPP	CI	RI	%T10	%T1	%NC
Plant & Animal Science	73	1427	19.6	4.08	4.29	49	19	4
Molecular Biology & Genetics	38	686	18.1	1.03	1.17	18	0	0
Biology & Biochemistry	21	365	17.4	1.85	2.69	19	10	14
Environment/Ecology	6	16	2.7	0.54	0.78	0	0	0
Agricultural Sciences	1	14	14.0	12.96	12.96	100	100	0
All research fields	139	2508	18.0	2.01	3.10	35	12	4

8. Mutual advantages to the use of repository contents in bibliometric analyses for Wageningen UR entities

The application of the Wageningen UR repository WaY for the selection of articles for the evaluation of scientific output and citation impact of Wageningen UR entities gives advantages to the efficiency and quality of both the repository and the bibliometric analyses.

For the repository, complete coverage and timely registration of new publications is stimulated because by registration of these publications in WaY, the Wageningen UR entities ensure that also their new scientific output will be included in future bibliometric analyses. The meta data in WaY is entered by the secretaries and checked by the research staff of Wageningen UR at the registration of new publications in Metis as well as double checked on a regular basis by staff from Wageningen UR Library. Besides these checks, errors in the meta data and coverage of the scientific output from Wageningen UR in WaY is checked when bibliographical records in Metis and WaY are matched with the corresponding ones in WoS. Additions as well as corrections that are made on the bibliographic records for Wageningen UR scientific output are registered in Metis and WaY and thereby are ensured for inclusion in future analyses and uses of meta data such as generation of publication lists, etc.

For the advanced bibliometric analyses that Wageningen UR Library performs on Wageningen UR entities, quality is improved by a more precise selection of the right articles for the entities under evaluation due to reliable and updated registration of affiliation data and work relations. Moreover, by using the repository for selection of scientific output, custom-made bibliometric analyses can be performed almost “on the fly” and comparative research evaluations can be performed in a fast and efficient way.

By the establishment of a connection between meta data on affiliation and work relations in the repository WaY and bibliometric data from WoS and ESI a system has been developed in which bibliographical information on new publications is entered when they are registered in the research registration system Metis. For this system updates on the bibliometric data can be performed efficiently and on a regular basis. Finally, the bibliometric analyses performed by Wageningen UR Library in this way has improved awareness of library services considerably. Wageningen UR Library is consulted for questions with regard to steps that can be taken to improve publication strategies for staff members, research groups or institutes.

References

- Gerritsma, W., (2006). Een systeem voor citatieanalyses in de praktijk. *InformatieProfessional*, 10, 12-17.
- Van Raan, A.F.J., (2004). Measuring Science. Capita Selecta of Current Main Issues, in *Handbook of Quantitative Science and Technology Research : The use of Publication and Patent Statistics in Studies of S&T Systems*, Moed, H.F., Glänzel, W., and Schmoch, U. (eds). (Kluwer Academic Publishers, Dordrecht), pp. 19-50.