Exploring Scientific Research Disposition from the Perspective of Academics

Roeland M. Van der Rijst*, Jan H. Van Driel, Jan W. Kijne & Nico Verloop
Leiden University, the Netherlands

Abstract
Many universities are searching for ways to strengthen linkages between research, teaching and learning. However, at universities intangible elements of research practice, like scientific research disposition, often remain implicit. Giving explicit attention to these elements might improve both university teaching as well as student learning. In particular, understanding differences and similarities of academics' scientific research dispositions can help to enhance links between research, teaching and learning. The aim of present study is to explore various aspects of scientific research disposition of academics. This phenomenographic study into academics' conceptions provides a full qualitative variation of aspects of scientific research dispositions. Participants were 23 academics from the departments of mathematics and natural sciences at Leiden University. Academics varied in research experience, and represented the disciplines within the departments. Six different aspects of scientific research dispositions were categorised in the phenomenographic analysis of interview transcripts; (1) inclination to know, (2) to share, (3) to be critical, (4) to achieve, (5) to understand, and (6) to be innovative. This categorisation reflects the qualitative variety of all aspects within scientific research dispositions of academics. Participants put different emphasis on aspects of their scientific research disposition. The results of this study provide academics with extra knowledge about research practice and scientific research dispositions. Profound understanding of scientific research dispositions can be useful during university teaching of scientific research.

Introduction

Studies into scientific research practice have shown that the idea of a common single scientific method is overly misleading. Many scholars have presented more broad-minded pictures about the phenomenon of scientific research (cf. Bauer, 1992; Latour & Woolgar, 1979; Rowbottom & Aiston, 2006). Generally, these studies were undertaken to provide a better understanding of research practice from the perspective of researchers' personal experiences. Although, scientific practices are highly personal, these studies show that generalizable sets of common categories can be distinguished. These *'categories of description'* (Marton, 1981, 1986) provide understanding of what scientific research actually is from the researchers' perspective.

A profound understanding of scientific research practice is necessary when teaching students to undertake scientific research at universities. Throughout last decades the call for strengthening linkages between research, teaching and learning at universities, has been answered by a large amount of studies from various countries (cf. USA: Boyer, 1990; Boyer-Commission, 1994 and 1998; Australia: Brew, 2006; UK: Barnett, 2005; Griffiths, 2004; Healey, 2005; Jenkins, Blackman, Lindsay & Paton-Saltzberg, 1998; Netherlands: Elsen, Visser-Wijnveen, Van der Rijst & Van Driel, 2007). These studies present positive views on stimulating student learning by developing pedagogies and instructional approaches aimed at enhancing these links in higher education institutions. Knowledge of scientific research practice and understanding experiences of academics can be helpful when looking for ways to link research, teaching and learning.

Every researcher has a personal tendency to act in a specific way when undertaking scientific research. Some researchers, for example, might strongly focus on critically investigating literature and observations from their experiment. Others, however,

* Correspondence to: Roeland Van der Rijst; e-mail: rrijst@iclon.leidenuniv.nl

might tend more towards developing new innovative instruments or ideas. Although common categories of these idiosyncratic scientific research dispositions of researchers provide understanding of research practice, there is an absence of systematic investigations into researchers' dispositions. In many university courses explicit attention is given to disciplinary knowledge as well as to disciplinary research skills. However, less attention is given to dispositions students need to become proficient researchers. Furthermore, in every research discipline, like mathematics and science, certain dispositions are preferred and valued, like the inclination to be critical, to be curious or to be innovative. Although academics have much experience in research as well as in teaching, they rarely explicitly express these preferred inclinations to act. The idea underlying the present study is that focusing on scientific research dispositions might positively influence university teaching and student learning in research intensive environments. Focusing explicitly on which the aspects of scientific research dispositions can provide students with a more realistic picture of scientific practice, guiding their own research experiences.

The aim of present study is first to identify full variation of aspects of scientific research disposition from the perspective of academics, and secondly, to describe commonalities between their dispositions. Understanding differences and similarities between preferred and valued tendencies to act can be helpful when developing pedagogies and approaches to enhance linkages between research, teaching and learning, for example, by emphasizing what teachers need to focus on to encourage students' understanding of scientific research practice. This study provides academics with knowledge about the nature of scientific research, valuable when stimulating student research competence.

Background

It is almost trivial to note that every researcher has tendencies to act when performing scientific research, e.g. tendency to innovate, to seek understanding, to share new insights, new ideas. We label these idiosyncratic combinations of tendencies to act as 'dispositions'. Thus a researchers' scientific research disposition is the idiosyncratic mixture of tendencies to act, while performing scientific research. Although scientific research dispositions are idiosyncratic, similarities between aspects in researchers' dispositions can be expected, similar to Marton's (1981, 1986) *'categories of description'*. Although, each individual has its own personal conceptions of phenomena, similar categories of description appear in different situations and for different individuals (Åkerlind, 2005). In present phenomenographic study the full variation of aspects of researchers' scientific dispositions is categorized.

In correspondence with psychological literature (Albarracin, Johnson & Zanna, 2005), we refer to the changeable tendencies to act in scientific research practice as to scientific research disposition of an individual. Although dispositions are difficult to change, individuals can put more emphasis on certain aspects of a disposition above others. To become proficient researchers, students need to acquire disciplinary research dispositions alongside disciplinary knowledge and skills. Some of these dispositions are highly valued, because they are perceived to be beneficial to the process of knowledge development. For example, the inclination to be critical to any received information is perceived as a desirable disposition by some scientists. Very few references to tendencies to act in scientific research are present in literature. De

Vos & Genseberger (2000) assume three aspects of disposition specific to scientific research; inclination 'to know', 'to be critical', or 'to share' knowledge.

Scientific research dispositions are part of an intangible connection between research and teaching at universities. A study by Neumann showed that academics conceive relations between research and teaching in three distinct ways, i.e. (1) global connection, (2) tangible connection, and (3) intangible connection (Neumann, 1992). The global connection describes the nexus at departmental level, and relates to research activity at department, which can guide teaching activities in university courses. The tangible and intangible connections describe the relations on an individual level. Neumann defined the intangible connection between research and teaching as related to issues concerning students developing an approach and attitude towards knowledge development and research. While the tangible connection emphasizes the transmission of advanced knowledge and results from recent research, the intangible connection relates to more implicit relations between research, teaching and learning.

Although, dispositions towards scientific research are acquired by students during their university study, there are relatively few moments during university courses where students explicitly reflect on the nature of scientific knowledge development. Through explicating scientific research dispositions and scholarly approaches more openly, students can be stimulated to acquire aspects of dispositions and students are offered possibilities to create a realistic understanding of scientific research process and products.

Methodology

To identify the full qualitative variation in aspects of scientific research disposition, a phenomenographic approach was chosen. A semi-structured interview was designed and administered among 23 academics, providing them with multiple opportunities to raise matters they considered important, relating to scientific research practice. To reduce contextually selective representation of aspects of research dispositions by participants, the interview questions were presented in two different contexts in which academics work; research context and teaching context. Participants were affiliated with the mathematics and science departments of Leiden University, which is a research university. Participants were selected from all disciplines within the departments. All were engaged in research in areas similar to their courses. Interviews were transcribed verbatim and analyzed using a phenomenographic approach, creating categories. From the analysis of the interviews with academics a descriptive categorization schema of aspects of scientific research disposition was constructed, while staying as close as possible to the original data. During the analysis of differences and similarities between academics' scientific research dispositions were studied.

Participants

Before selecting participants two issues were considered. Firstly, the sample should cover the variety of research traditions within natural science and mathematics as present in the department of Mathematics and Natural Sciences at Leiden University. Secondly, a variety of experience in research as well as in teaching of participants should be enclosed in the sample.

From each of the nine educational institutes of the department three academics with different academic positions, who were teaching undergraduate courses, were asked to participate. During the time in which the interviews were held, a pedagogical course for new university teachers took place. All eleven academics following this course were also asked to participate. Finally, 41 faculty members were sent an electronic mail to ask for their cooperation. From the approached academics 31 responded from which 23 (56%) were able to be interviewed during the selected period of time. Table 1 presents the academic positions of all 23 participants at university.

Position	*Absolute number*	*Percentage*
Full professor	6	26%
Associate professor	3	13%
Assistant professor	9	39%
Post-doctoral researcher	1	4%
Lecturer	4	17%
Total	*23*	*100%*

Table 1: Position at university of participants

The main reason for not participating was staying abroad or no available time to be interviewed. From the participants six (26%) were female academics. All lecturers, participating in this study, were PhD graduates. When asking questions about their own scientific research dispositions, the lecturers were stimulated to reflect on their previous research activities. Table 2 presents the educational institutes of the participants. All participated, or had participated, in research areas similar to the areas in which they taught courses.

Educational institute within department of Mathematics and natural sciences at Leiden University	*Absolute number*	*Percentage*
Mathematics	4	17%
Computer science	1	4%
Physics	4	17%
Astronomy	5	22%
Chemistry	2	9%
Sustainable molecular science & technology	1	4%
Bio-pharmaceutical sciences	2	9%
Biology	2	9%
Life Science & technology	2	9%
Total	*23*	*100%*

Table 2: Educational institutes within department of Mathematics and natural sciences at Leiden University of participants

Procedure

To do justice to the two different contexts in which academics work, the interview questions were divided into two parts related to two different contexts in which academics work; teaching context and research context. The first part of the interview consisted of questions concerning the teaching context and the second part consisted of questions concerning the research context. The two parts of the interview were held at two distinct moments in time. Interview questions were designed to be flexible, offering participants possibilities to raise matters they considered to be important. Two pilot interviews were held, with an educational expert in the field of science

teaching and with an expert in the field of science research. Both were not participating in main study. After analysing the pilot interviews, questions were adapted with respect to their comments.
The semi-structured interview consisted of two parts. The interview questions of part one can roughly be categorised into four sets of questions; (1) participants' experience in teaching, (2) perceived objectives of university education, (3) scientific research dispositions for student to acquire, and (4) students' behaviour related to scientific research dispositions. Questions in part two can be categorised into three sets; (1) participants' experience in research, (2) academics' scientific research dispositions, and (3) academics' behaviour related to scientific research dispositions. Interviews were held in two sessions of approx. 45 minutes and respectively 35 minutes, with intermediate time of approx. 2 days. All interviews were transcribed verbatim and were sent to participants for member check.

Interviews transcripts were analysed creating codebook and categories. The aim of the analysis was to capture full qualitative variation of aspects of scientific research dispositions conceptualised by academics in science and mathematics.

Findings
Six qualitatively different aspects of scientific research dispositions could be distinguished from the data. Three of these aspects were also describe by De Vos & Gensenberger (2000); inclination to know, to share, and to be critical. Three aspects of scientific research disposition, i.e. (a) inclination to understand, (b) to do, and (c) to be innovative, were additional to the aspects found in literature. All six aspects reflect the qualitative variety in which academics conceptualise scientific research disposition.

Participants made a clear distinction between (1) inclination 'to know' and (2) inclination 'to understand'. Understanding phenomena on a fundamental level is conceived differently, than initial curiosity of knowing facts or theories. Furthermore, many academics consider the tendency to be innovative, to be creative, and to have an open mind as important aspects of a disposition of a scientific researcher. These were categorized under (3) inclination 'to be innovative'. Participants also consider dedication and commitment towards scientific workmanship quite important to be proficient within the scientific community. These aspects of scientific research disposition were categorized under (4) inclination 'to achieve'. Furthermore many participants indicate that an (5) inclination 'to be critical', i.e. critical towards own work and towards work of others, and an (6) inclination 'to share' knowledge both are highly valued in scientific communities. All six aspects reflect the qualitative variety of academics' conceptualization of scientific research dispositions.

The various participants put different emphasis on their conception of the most important aspects of scientific research disposition. Most participants conceived one aspect to be central to scientific research disposition, but which aspect was central varied among the participants. Two aspects, inclination to understand and to be critical, were identified most often. The following two quotes illustrate how two academics conceive different aspects to be central; the fragments are coded as inclination 'to understand' and 'to be critical', respectively:

"Curiosity is a major motive, should be a major motive. Yes, the desire to understand how something works and to experience the thrill when you understand it, when you solved the issue." (Astrophysics 1; to understand)

"To be critical is most important. They [students] have to weight all information they receive, not only from literature, but also the results from their own experiments. […] many things can be related to that, open attitude, open towards other ideas and towards different results, […] but all is much related to being critical." (Physics 2; to be critical)

Some participants considered aspects of scientific research disposition of researcher and scientific research disposition for student to be similar. Others showed important differences in their conception of scientific research disposition of researcher and scientific research disposition for student to acquire. The following two quotes illustrate difference in conceptualisation of scientific research disposition of one participant, respectively about scientific research disposition for students and scientific research disposition of researchers.

"That they [students] are passionate about a subject to a certain extent, and trying to understand issues by themselves through reading more information about it. That is very important." (Biology 1, students)

"The ability to ask exiting new questions and to create new mental images, originality is important. Some people are good researchers, but they follow standard procedures. Others are better, recognizing new areas of research." (Biology 1, researchers)

In the first quote the emphasis is put on students embracing an intrinsic inclination to understand the topic. For researchers, however, this participant puts the emphasis on a disposition to develop original questions and new ways to answer these questions. This difference also indicates that not all aspects of scientific research disposition need to be acquired during undergraduate years, some aspects, e.g. inclination to be innovative, might be acquired in a later stage.

Discussion

The results of this study present a more diverse picture about how academics conceptualise scientific research disposition. Aspects of scientific research disposition, which existed tacitly among academics, are made accessible. Academics rarely express which aspects of scientific research disposition they value in their discipline. However these conceptions can be convincingly informative when identifying how academics design and redesign their courses. Therefore a profound understanding of scientific research disposition can also be used during professional development of academics. Furthermore, the results of this study may provide academics with extra knowledge about how to stimulate students' scientific research disposition during their classes. Still, further research is needed into scientific research disposition and their relations to teaching and learning to assess the actual effect of different teaching strategies to stimulate scientific research disposition for students.

Through the analysis of the interview transcripts, six qualitatively different aspects of scientific research disposition were distinguished. These aspects were (i) inclination

'to know', (ii) 'to be critical', (iii) 'to share' knowledge, (iv) 'to understand', (v) 'to achieve', and (vi) 'to be innovative'. Three of these aspects, *inclination to 'know', 'to be critical', and 'to share'*, were identified in literature about research dispositions and scientific attitudes (De Vos & Gensenberger, 2000), but were never based on empirical study of research experiences of academics. Three aspects, *inclination 'to achieve', 'to understand'*, and *'to be innovative'*, were additional to our understanding of scientific research dispositions of academics and provide new insights into scientific practice.

Although knowledge about scientific research dispositions can support both university teaching and student learning, academics rarely reflect explicitly on preferred and valued aspects of scientific research disposition in their discipline (cf. Neumann, 1992). All aspects of academics' scientific research dispositions, which exist tacitly among academics, were made accessible in this study. To assess the effect of different teaching strategies stimulating scientific research dispositions, further research is needed into academics' classroom practice. Results from this study provide us with new perspectives on academics' practice.

Now that most academics accept the fact that scientific practice is not based on a single scientific method, a more advanced perspective on scientific practice is becoming apparent. Every researcher, every academic, constructs his of her idiosyncratic scientific method from aspects which work best for that particular individual. We can communicate about our personal scientific methods because the aspects are generalizable between different situations. Therefore, academics explicating experiences of their research practice during university teaching can be of great value to student learning in research intensive environments.

Correspondence: Roeland M. Van der Rijst, ICLON - Leiden University Graduate School of Teaching, Wassenaarseweg 52, P.O. Box 9555, NL-2300 RB, Leiden, the Netherlands.

References

Åkerlind, G.S. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research & Development 24*(4), 321-334.

Albarracin, D., Johnson, B.T. & Zanna, M.P. (eds.) (2005). *The Handbook of Attitudes*. London: Lawrence Erlbaum Associates.

Barnett, R. (Ed.) (2005). *Reshaping the University: New Relationships between Research, Scholarship and Teaching*. McGraw Hill / Open University Press, 67-78.

Bauer, H.H. (1992). *Scientific Literacy and the Myth of the Scientific Method*. Urbana: University of Illinois Press.

Boyer, E. L. (1990). *Scholarship Reconsidered: Priorities of the Professoriate.* Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

Boyer-Commission (1995). *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. Carnegie foundation for the advancement of teaching.

Boyer-Commission (1998). *Reinventing Undergraduate Education: Three Years after the Boyer Report*. Carnegie foundation for the advancement of teaching.

Brew, A. (2001). Conceptions of research: A phenomenographic study. *Studies in Higher Education 26*(3), 271-285.

Brew, A. (2006). *Research and Teaching: Beyond the Divide*. New York: Palgrave MacMillan.

De Vos, W. & Genseberger, R. (2000). 'Onderzoek doen' in de natuurwetenschappelijke vakken. (English translation: 'Doing Research' in Science Subjects) *Tijdschrift voor didactiek der bètawetenschappen 17*(1), 4-13.

Elsen, G.M.F., Visser-Wijnveen, G.J., Van der Rijst, R.M., & Van Driel, J.H. (2007). *How to Strengthen the Connection Between Research and Teaching in Undergraduate University Education*. Leiden: ICLON-Leiden University Graduate School of Teaching.

Griffith, R. (2004). Knowledge production and the research-teaching nexus: The case of build environment disciplines. *Studies in Higher Education 29(6)*, 709-726.

Healey, M. (2005). Linking Research and Teaching to Benefit Student Learning. *Journal of Geography in Higher Education 29*(2), 183–201.

Jenkins, A., Blackman, T., Lindsay, R., & Paton-Saltzberg, R. (1998). Teaching and research: student perspectives and policy implications. *Studies in Higher Education 23*(2), 127-141.

Latour, B. & Woolgar, S. (1979). *Laboratory Life: the Social Construction of Scientific Facts*. Los Angeles: Sage.

Marton, F. (1981). Phenomenography - Describing conceptions of the world around us. *Instructional Science 10*, 177-200.

Marton, F. (1986). Phenomenography - A research approach to investigate different understandings of reality. *Journal of Thought 21*(3), 28-49.

Neumann, R. (1992). Perceptions of the teaching-research nexus: A framework for analysis. *Higher Education 23*(2), 159-171.

Rowbottom, D.P. & Aiston S.J. (2006). The myth of 'scientific method' in contemporary educational research. *Journal of Philosophy of Education 40*(2), 137-156.