The research-teaching nexus in the sciences : scientific research dispositions and teaching practice

Rijst, R.M. van der

Chapter 5

Associations between teachers' intentions and students' perceptions of the research intensiveness of learning environments

5. Associations between teachers' intentions and students' perceptions of the research intensiveness of learning environments[4]

Many factors have already been recognised as possible explanations of why teachers in higher education teach the way they do. Teaching intentions are additional explanatory factors for differences in teaching; these are especially of interest, because intentions initiate teachers' actions. In this study, we examined in what ways specific teachers' intentions regarding the integration of research in teaching are related to students' perceptions of the learning environments. Interviews were held with university science teachers (n=11), and a questionnaire was presented to their students (n=104). The results show that teachers' intentions related to tangible elements of the integration of research in teaching, such as the use of academics' own research during the courses, are relatively more congruent with students' perceptions than are intangible elements, such as stimulating the development of research dispositions. The results indicate that if students are to perceive and appreciate the intangible elements of research, academics need, first, to become more aware of these elements and, second, to take more care in explicitly drawing students' attention to these elements during science courses.

[4]This chapter is to be submitted in an adapted form as:
Van der Rijst, R.M., Visser-Wijnveen, G.J., Kijne, J.W., Van Driel, J.H., & Verloop, N. *Associations between teachers' intentions and students' perceptions of the research intensiveness of learning environments.*

5.1 Introduction

Many factors influence the way teachers at university teach their courses. In research into teaching in higher education, much attention has been given to factors such as conceptions of teaching and learning (Kember 1997; Oolbekkink-Marchand, Van Driel, & Verloop, 2006; Pajares, 1992; Visser-Wijnveen, et al., in press), orientations towards teaching (Kember & Gow, 1994; Samuelowicz & Bain, 2001), and approaches to teaching (Stes, Gijbels, & Van Petegem, 2008; Trigwell & Prosser, 2004). Other factors which have been recognised as explanations of why different teachers teach differently include teachers' pedagogical repertoire, teaching skills, and the sophistication of their subject matter knowledge. Although this listing of elements of the knowledge base of teachers (Verloop et al., 2001) in higher education is not exhaustive, it provides multiple explanations for differences in teaching in higher education. In a study among university teachers, Martin and colleagues (2002) discussed a critical issue in why teachers teach differently, namely, the differences in their goals and objectives for teaching and learning in their courses. According to Norton and colleagues (2005), teachers' intentions reflect a compromise between teachers' conceptions of teaching and their academic and social contexts. On the one hand, teachers' intentions are influenced by their abstract notions of what teaching and learning should involve; on the other hand, their intentions are also influenced by the context in which they teach their courses. The factors which influence intentions are also reflected in the Theory of Planned Behaviour (Ajzen & Fishbein, 2005). In this model of human behaviour, three kinds of cognitive factors determine a person's intention to act: attitude towards the action, the subjective norm, and perceived control over the action. Intentions initiate the actions of a person. This intervening position between conceptions and actions makes teachers' intentions a valuable object of research. Many research findings on conceptions of teaching and learning show an ambiguous relationship between conceptions and teaching practice (Murray & MacDonald, 1997; Samuelowicz & Bain, 1992); others show a strong congruence between teachers' intentions and their teaching practice when the context of teaching is clearly defined (Martin et al., 2002; Norton et al., 2005; Prosser, Martin, Trigwell, Ramsden, & Middleton, 2008). Teachers' intentions can give us more insight into the relationships between teachers' cognitions and teaching practice. In this study, we considered university teachers' intentions regarding the nexus between research and teaching in their courses.

5.1.1 Intangible elements in the research-teaching nexus

Neumann (1994) distinguished between the 'tangible nexus' and the 'intangible nexus' in the integration of research and teaching at universities. In the tangible nexus, the clearly visible, explicit forms of integration of research and teaching are categorised, such as teaching 'research practicals'. In the intangible nexus, the more tacit, not directly observable forms of integration of research and teaching are grouped, such as creating an inquisitive research climate, fostering an innovative atmosphere, or stimulating the development of students' research dispositions. Intangible elements have often been denoted by teachers and by educational researchers as relevant elements of learning to do research, but few researchers (McLean & Barker, 2004; Elen & Verburgh, 2008; Elen et al., 2007) have addressed the relation between these intangible elements of the research-teaching nexus and student experiences of courses. Research dispositions are an element of the intangible nexus. In Chapter 2, six qualitatively different aspects of the scientific research disposition of academics were presented: inclination (1) to achieve, (2) to be critical, (3) to be innovative, (4) to know, (5) to share knowledge, and (6) to understand (Van der Rijst, Kijne, Verloop, & Van Driel, 2008). Table 5.1 presents the six aspects with an illustrative quote from university teachers about each aspect. The research dispositions of academics are different from the research dispositions of students. Academics are experts in research and often have a well-explicated research disposition, while students have less experience and may have ambiguously expressed, or underdeveloped, research dispositions. Although the research dispositions of academics and students may be different, we assumed that the research dispositions of both groups would comprise the same six aspects.

5.1.2 Modes of integration of disciplinary research into teaching

Healey (2005b) and Jenkins and colleagues (2007) suggest that the possibilities of integrating research in teaching can be described according to two dimensions: (1) running from emphasis on research products to emphasis on research process, and (2) running from students as an audience to students as participants of research activities. These dimensions divide the two-dimensional plane into four quadrants, which have been characterised as four qualitatively different approaches to integrating research into university teaching. Figure 5.1 shows the four quadrants, in which the vertical axis depicts the student role, and the horizontal axis shows on which research aspect the emphasis is put in a course.

Table 5.1 Categories of scientific research dispositions illustrated with quotes

Aspect of scientific research disposition	Illustrative quote
Inclination to achieve	Dr. Susan: But some people just can't, it is insecurity; research, there is an awful lot of insecurity in research. Some people just can't take it.
Inclination to criticize	Dr. Simon: Being critical of oneself, and of the sources: 'Is it correct what I argue?' So, what are the proper sources, which sources are trustworthy, and even when a source is trustworthy, read it again.
Inclination to innovate	Dr. Susan: And two students actually asked if they could come in the next day and do their experiment, because they didn't have everything they wanted, and they turned up with old stuff to make bread and they put my yeast into this mix to see if they were going to get bread or not. This is probably one of the most original solutions that anybody has come up with. So I liked that one.
Inclination to know	Dr. Nathan: But you really have to try hard to stimulate their curiosity and their inquisitive attitude.
Inclination to share	Dr. Carlos: Although they just study well-known mathematical maxims, by studying for themselves they create an attitude similar to the attitude of a researcher in the field of mathematics. In research you have to read articles and explain your ideas to come to new suggestions as to how to solve your problem. In that sense a research attitude is created among students or researchers.
Inclination to understand	Dr. Charles: You always need to ask yourself if you really understood what was going on in such a situation. It does depend how broadly you define 'research', but I belief that this aspect is part of this more practically oriented student research project.

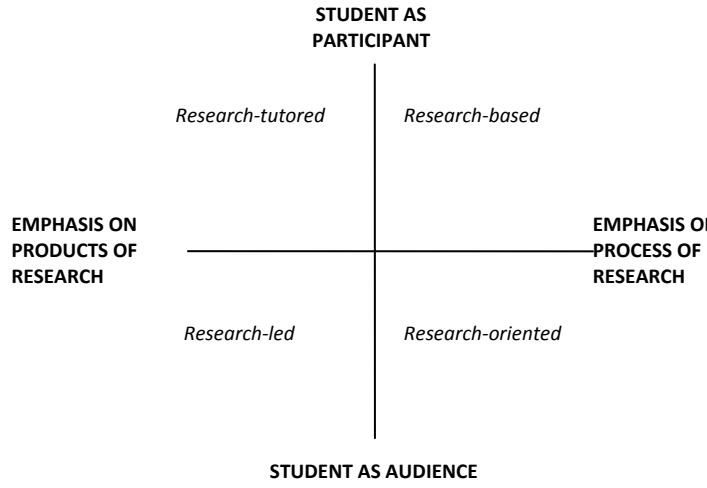

Figure 5.1 The four modes of the research-teaching nexus (cf. Healey, 2005b)

Healey (2005b) labelled the two bottom quadrants of this model as 'research-led' and 'research-oriented'. In these two modes, students are perceived as an audience in research activities, in the sense that they do not directly contribute to the development of scientific knowledge. Neither end of the scale, 'students as audience' or 'students as participants', should be interpreted as passive or active student engagement; they should be regarded as related to students working on developing their own knowledge and skills, or on developing new knowledge in the discipline, respectively (Elsen et al., 2009). Students might work actively on improving their own knowledge and skills, without aiming to contribute new knowledge to the discipline, and thus still score high on the element 'student as audience'. The 'research-led' and 'research-oriented' modes can be discerned in the difference between emphasizing research products and emphasizing the research process. In the 'research-tutored' and 'research-based' modes, students participate in research while focusing on the development of new knowledge in the discipline. This heuristic model provides us with a tool to broadly understand the main orientation towards the nexus of research and teaching in the courses, but we have to keep in mind that each course can be subdivided into smaller units, such as assignments, assessments, and instructions, which in their turn can deviate from the overarching general mode of the course. For example, in a course with an overall emphasis on the process of research,

such as a research practical on thermodynamics in which students examine the behaviour of gases, the teacher can choose to insert a lecture on the behaviour of ideal gases as a product of research. In this study, therefore, we kept in mind the ambiguity in the dimensions of this heuristic model, and considered the four modes as qualitatively distinct ways to consider the emphasis in courses on the integration of research into teaching. Healey's four quadrants provide an indication of how to categorize courses based on their general emphasis (Elsen et al., 2009).

5.1.3 Students' perceptions of the research intensiveness of learning environments

Several studies into the quality of student evaluations of learning environments show that students' perceptions are a valid and reliable source of data about teachers and teaching (Braskamp & Ory, 1994; Cashin & Downey, 1992; Marsh & Roche, 1997). Marsh and colleagues (2002) conclude that student evaluations of research environments are reliable and stable, and that, therefore, students' perceptions of learning environments are an effective method for gathering data about characteristics of learning environments (cf. Mainhard et al., 2009). Additionally, how students perceive the learning environment largely determines the final effect of a course. For example, when a student perceives an assignment as irrelevant, it is likely that this student does not exploit the full learning opportunity. In an overview of research into students' perceptions of learning environments in which a strong integration exists between research and teaching, Jenkins and colleagues (2003) show that students are more motivated when they encounter staff research at the institute at an early stage in their studies. Students experience courses as up to date and intellectually stimulating when teachers bring into play elements of their own research during their courses. According to the students, teachers become more enthusiastic when bringing up their own studies (Jenkins et al., 2003). The credibility of the staff and the institute increases when teachers have research responsibilities as well (Jenkins et al., 1998). Furthermore, students perceive a positive relationship between doing research projects and their learning (Turner et al., 2008). Finally, students appreciate being socially and intellectually involved in a research group (Healey, 2005b). Robertson and Blackler (2006) showed in an interview study that students in a research-intensive learning environment experienced 'pride', and were motivated by the enthusiasm of their teachers. Students are intellectually challenged by close involvement with research-related activities. Healey and colleagues (in press) summarised the main findings of studies into students' perceptions of the

relevance of research for their learning. The advantages of a close connection between research and teaching, according to the students, are the enthusiasm of the teachers, the credibility of the staff, and the stimulus of being taught by a 'well-known' scientist. Furthermore, students experience that being actively involved in research activities increases their development of skills and their awareness of the research process (Healey et al., in press; Turner et al., 2008). An important disadvantage of the involvement of teachers in research activities was the decline in availability of the staff. Additionally, when students are only partially involved in the research projects of their teachers, they do not always develop a sense of ownership of the project (Healey et al., in press). Thus, research-intensive learning environments have advantages for student learning, but they also have some disadvantages.

5.1.4 Research question

The aim of this study was to identify associations between teachers' intentions related to the research-teaching nexus and the students' perceptions of the research intensiveness of the learning environments. The rationale behind this aim was to gain a greater understanding of the associations between teachers' intentions which are put into practice and students' perceptions. We considered teachers' intentions regarding the emphasis on research in their courses; we were interested in their intentions regarding both tangible and intangible elements of the research-teaching nexus. Therefore, the central question in this study was *what associations can be identified between teachers' intentions and students' perceptions of the research intensiveness of university science courses?*

5.2 Methods

5.2.1 Sample

The participants were university science teachers (n=11) and their students (n=104) from the Faculty of Science of Leiden University. Teaching staff with a research task as well as involvement in courses with a research component were asked to participate. The participating teachers volunteered to contribute to this study. The positions of the teachers varied from assistant to full professor, and represented six sub-disciplines within the natural sciences and mathematics, namely, astrophysics, biology, chemistry, computer science, mathematics, and physics. The term course was used in this study to indicate a curricular unit for which students get a certain number of credits, such as a series of lectures, practicals, or group-work sessions. The contents of the courses reported in this study were related to research in very diverse ways. Some courses were directly

related to doing research, such as research practicals or research internship; others were more focused on listening to researchers, such as lectures from visiting professors or seminars about current research topics. The amount of time students were supposed to invest in each course varied between 28 hours and 196 hours of study load.

5.2.2 Procedure

During fall and winter 2007, the courses of the participating teachers were followed as part of a larger project which was focused on the research-teaching nexus in the sciences. Before the courses started, the participating teachers were interviewed about their intentions for the particular courses. During the last meetings of the courses, students were asked to complete a questionnaire about the research intensiveness of the learning environment (Van der Rijst et al., 2009). In total 69% (104) of the students who followed the courses completed the questionnaire. The response rates of individual courses varied between .25 and 1.00. Table 5.2 depicts the educational institutes, the method of instruction, and the response rates of the questionnaire per course.

Table 5.2 Background information of courses and response to the questionnaire

Teacher	Educational institutes	Year of study (bachelor's phase)	Method of instruction	Absolute response (response rate)
Dr. Adam	Astrophysics	2	Seminar	9 (.75)
Dr. Nathan	Astrophysics	1	Practical	18 (.90)
Dr. Tanya	Biology	2	Lecture	2 (.25)
Dr. Susan	Biology	1	Practical	10 (1.00)
Dr. Simon	Chemistry	1	Practical	2 (.33)
Dr. Paul	Chemistry	2	Practical	2 (1.00)
Dr. Edward	Chemistry	2	Practical	3 (1.00)
Dr. Charles	Computer Science	2	Seminar	8 (.53)
Dr. Howard	Computer Science	1	Seminar	39 (.87)
Dr. Carlos	Mathematics	3	Lecture	3 (.38)
Dr. Eliot	Physics	1	Lecture	8 (.53)
				104 (.69)

5.2.3 Interview about teachers' intentions

The aim of the pre-course semi-structured interviews with the participating teachers was to retrieve their intentions before teaching the courses. The interviews comprised four structured questions, which were used to guide the conversation between interviewer and interviewee. The teachers were given multiple opportunities to raise matters which they considered to be important, and were asked to explain issues which were unclear to the interviewer or to give clearer explanation of the rationale behind a statement. Two questions were asked about general goals and objectives for the course. The teachers were asked, first, to give a general explanation of the course ('Can you give a general description of the course?') and, second, to explain more specifically what they aimed to achieve during the course and how ('Explain what you intend to achieve during the course and how you intend to achieve that'). The third and fourth questions related to the intended support of the development of students' research dispositions, such as critical thinking, curiosity, or creativity ('In what way is research present in the course?,' and 'In what way are you going to stimulate or support students' attitude, inclination or manner in these research activities?'). In the responses during this interview, both tangible and intangible elements of teachers' intentions were present. Teachers' intended modes of the research-teaching nexus and their intentions to arrange research were considered tangible elements of the nexus, while support of students' research dispositions in the courses was considered an intangible element.

5.2.4 Student questionnaire on research intensiveness of learning environments

In order to measure students' perceptions of the learning environments, we used a previously developed questionnaire on the research intensiveness of learning environments (Van der Rijst et al., 2009). Three sources can be distinguished as the origins of the items in this questionnaire. First, the heuristic model of Healey (2005b) about modes of the research-teaching nexus was used to find indications of tangible elements of the research-teaching nexus. Second, from the *Postgraduate Research Evaluation Questionnaire* (PREQ; Marsh et al., 2002), items which focused on intangible elements of the nexus and research facilities, such as infrastructural needs or availability of staff, were retrieved. Third, items from the questionnaire of Verburgh and Elen (2006) about the research-teaching nexus were used to inform items in the student questionnaire about both tangible and intangible elements. The questionnaire used in this study consisted of three parts related to both intangible and tangible aspects of research in university courses. Part A of the questionnaire included the tangible attention paid to research during

Table 5.3 Scales of the student questionnaire with Cronbach's alphas and exemplary items

Scale	Alpha	Exemplary item
A1 – Attentiveness to doing research (11 items) concerns the extent to which research was addressed during the course according to the students.	.95	During this course clear relationships were drawn between research and teaching content.
A2 – Becoming acquainted with recent research (5 items) concerns the amount of attention for recent research problems and results.	.89	During this course my awareness grew about the problems researchers struggle with at this moment.
A3 – Participating in research (5 items) concerns the extent to which students were involved in and/or contributed to research.	.90	During this course we searched for answers to as yet unresolved scientific questions.
A4 - Using research of teacher (4 items) concerns the amount of attention given to research activities of the particular teacher.	.91	During this course I got acquainted with the research of my teacher(s).
B1 – Stimulating a scientific research disposition (7 items) concerns the extent to which students were stimulated to develop a critical, scientific research disposition.	.86	During this course the teacher(s) urged us to ask critical questions about our work.
B2 – Integration in a research community (3 items) describes to what extent students were socially engaged in the research environment and appreciated the research climate of the educational institute.	.82	During this course I had opportunities for social interaction with researchers of the institute.
B3 – Motivation for research activities (3 items) concerns the extent to which students were stimulated to develop academically.	.85	During this course I felt stimulated to engage in further study in this research domain.
C – Quality of learning environment (10 items) describes the overall student satisfaction with the quality of the course, concerning issues such as availability of supervision and quality of ancillary facilities.	.90	During this course the teacher(s) taught me in an adequate way.

the course; it consisted of four scales, 'becoming acquainted with recent research', 'participating in research', 'attentiveness to doing research', and 'using research of teacher'. Part B contained three scales about intangible research elements: whether students perceived themselves to be involved in the research community, whether their motivation for research had increased, and whether the development of their scientific research disposition had been stimulated. Part C, a single scale, covered the ancillary facilities, such as the availability of supervision, the quality of infrastructural elements, and the clarity of learning goals. Students were asked to score the items according to how relevant they thought the statement was to the course. The five-point Likert scale ran from 'almost never' (1), through 'hardly ever' (2), 'sometimes' (3), and 'reasonably often' (4), to 'almost always' (5). For every scale, Cronbach's alpha, means, and standard deviations were calculated for the present sample of science students (n=104) of the participating teachers. Reliabilities of the scales, measured using Cronbach's alpha, varied between .82 and .95. Table 5.3 shows the eight scales from the questionnaire with reliabilities and illustrative example items.

5.2.5 Analysis

The analysis of the interview data resembled classic content analysis (Krippendorff, 1980; Ryan & Bernard, 2000, p. 785), in the sense that we worked with pre-developed categories to code the data. Four phases can be distinguished in the analysis procedure. The *first* phase consisted of the development of a codebook. The categories used to code the data originated from three sources. (1) The scales of the questionnaire about the research intensiveness of learning environments (Van der Rijst et al., 2009) were used to identify teachers' intentions regarding the emphasis on research in their courses, in fragments of the responses to the first two questions of the interview. (2) The six aspects of scientific research dispositions (Van der Rijst et al, 2008) were used to identify in the responses to the third and fourth questions of the interview which aspects of students' research dispositions teachers intended to encourage. (3) The four modes of the research-teaching nexus (Healey, 2005b) were used to categorise how research was integrated in course activities. During the *second* phase, the interview questions were coded using ATLAS-ti as an electronic tool for qualitative analysis (Muhr, 1997). The transcripts of interview questions 1 and 2 were analysed using the part of the code book about the scales of the questionnaire, while interview questions 3 and 4 were coded using the part of the codebook about the aspects of research dispositions. The complete transcript was coded to retrieve the mode of the research-teaching nexus. During the *third* phase of the

analysis procedure, a qualitative data analysis matrix was composed with the teachers on the rows and average students' perceptions scores in the columns (cf. Table 5.5). In this matrix, those scales which were explicitly identified as intended in a course were highlighted, to identify congruency between teachers' intentions and students' perceptions. If an element was explicitly mentioned as intended in the course, and students rated that particular element high, congruence was assumed between teachers' intentions and students' perceptions. Similarly, if an element was explicitly mentioned as *not* intended in a course and students rated that particular element low, congruence was also assumed between teachers' intentions and students' perceptions. When the teacher did not mention an element, no assumption was made about intentions for the course concerning this element. This means that congruency could be determined only for those elements which were explicitly referred to during the interview. Congruency was assumed with students' perceptions larger than 3.50 for intended elements, and smaller than 2.50 for elements which were not explicitly part of teachers' intentions. Teachers who taught courses with similar modes of the nexus were clustered into groups to enable consideration of similarities between intentions to stimulate the development of research dispositions. In the *fourth* phase, teachers' intentions regarding the emphasis on research in their courses, and their intentions regarding the development of aspects of students' research dispositions, were combined with the mode of the nexus and with students' perceptions of the research intensiveness of the courses elicited from the questionnaire in a narrative way. These narrative descriptions were composed by first reading the transcript, and then listing all codes and inferring the teachers' intentions. Each course was characterised by one of the four modes of the research-teaching nexus (Healey, 2005b). The scale averages of the students' perceptions per teacher were added to the narrative descriptions to support a qualitative visual examination of correspondence between the variables. The overall means of all students per scale were calculated using the complete dataset, neglecting the nesting of students in classes.

5.3 Results

Teachers' intentions regarding their courses were described in a narrative format. The descriptions were clustered in groups according to mode of the research-teaching nexus. The descriptions are presented below, with fragments in italics for those codes which are characteristic of teachers' intentions identified in the interviews. The scale averages of students' perceptions per teacher were added to the narratives and can also be found in Table 5.5 (p. 127).

5.3.1 Teaching research-led courses

In a course with a research-led mode of the nexus, the emphasis is put on research products, such as the understanding of theories or models. Students are 'observers' involved in scientific research activities, such as in listening to a lecture by a researcher, or observing a simulation of an experiment.

Dr. Carlos's intentions for the course were mostly content-focused. The central issue in his lecture-type course was the transmission of understanding of the 'flavour' of mathematical argumentations. According to Dr. Carlos, this issue is the most relevant, and an important *disposition for research in that discipline*. This course consisted of lectures in which Dr. Carlos conveyed and explained some mathematical argumentations relevant to the course theme. At the end of the course, each student was asked to give a presentation about a topic from disciplinary research related to the theme of the course. Dr. Carlos explicitly did *not intend to ask for any participation in research activities from the students* other than sharing of ideas. Dr. Carlos's account of the course mode can be characterised as research-led. The students scored moderately low on all scales. Remarkably, the scale 'quality of the learning environment' (C; 4.60) was scored high. Furthermore, the students scored moderately high on stimulation to develop their research disposition (B1; 3.19), and were strongly motivated to pursue research (B3; 3.67).

Dr. Eliot's general intention for his course was to present students with invited speakers lecturing about *recent research*. Dr. Eliot perceived his role as that of 'chairman', who introduced the speakers and described the relations between the various topics. The most important goal for Dr. Eliot was to *motivate students for disciplinary research* by presenting research conducted within the institute. The description Dr. Eliot gave of this course can be characterised as research-led teaching. The students perceived a strong motivation for research (B3; 4.00) during the course meetings, and scored moderately high on the scale 'attention to research' (A1; 3.20). Furthermore, participation in research was scored very low (A3; 1.52).

According to Dr. Tanya, the focus of her lecture-type course was to *acquaint students with recent research*. Dr. Tanya planned to describe and explain the concepts in current theories and the most widely used research methods. Her students mostly listened actively to Dr. Tanya; *participation in research activities was not expected*. Dr. Tanya explicitly explained that one of her objectives was to *stimulate the development of students' dispositions* to think critically about the literature, hypotheses, and research questions. Dr. Tanya's description of the mode for this course can be characterised as research-led. The students did not

perceive themselves as participants in research (B3; 1.70) during this course, but were highly motivated to pursue research (B3; 4.50). Furthermore, the students perceived a strong stimulation to develop their research dispositions during this course (B3; 3.93).

5.3.2 Teaching research-tutored courses

In a course with a research-tutored mode of the nexus, the emphasis is put on research products, such as the understanding of theories or models. Students are 'participants' involved in research activities, such as in writing about theories and models, or by giving presentations about a topic of interest.

According to Dr. Simon, *not much attention would be given to scientific research* during his course. Dr. Simon explained that he *always tries to integrate own research of the faculty/institute* into his courses, and believes that this is not done enough. During this course, the *students would participate in literature studies, and not in empirical or experimental studies*. The students would present their findings to their peers in a conference format. Dr. Simon considered the study of the literature an essential part of scholarly activity. During his course, Dr. Simon planned to focus on argumentation skills and competencies. This description was in line with a research-tutored mode of the nexus. The students in this course scored high on the scales 'motivation for research' (B3; 4.00), 'recent research' (A2; 3.90), and 'stimulation of research disposition' (B3; 3.43). None of the scales were scored low compared to the other courses.

5.3.3 Teaching research-oriented courses

In a course with a research-oriented mode of the nexus, the emphasis is put on research processes, such as the gathering and analysis of data. Students are involved as 'observers' of the research activities, such as in repeating well-known experiments to develop certain research skills.

Dr. Charles explained that during his seminar, a combination of lecture and project, he planned to accustom students with and evaluate those *elements of recent research* which they would encounter during their professional careers. Dr. Charles explained that *his own fundamental mathematically oriented research would not be appropriate to discuss* during this practice-oriented course. Dr. Charles' description of his course resembled the research-oriented teaching mode of the nexus. Students scored low on almost all scales, except for the scales 'stimulation of research disposition' (B1; 3.04) and 'quality of teaching' (C; 3.55). The scale 'own research of teacher' (A4; 1.35) was scored lowest of all scales and of all courses by the students.

Dr. Howard explained that his course would focus on the development of practical skills. According to Dr. Howard, *scientific research will not be part of this course*. Only on second thoughts did Dr. Howard explain that the assignments would, in fact, have various research contexts. However, Dr. Howard said that although the assignments would be contextualised, the problems would be more general disciplinary problems. And the problems were designed to allow students to develop their problem-solving skills. Some issues, which were *still open questions in the field of disciplinary research*, were presented to the students in an adapted form. This course had a research-oriented teaching mode of the nexus. The students in this course judged the intensiveness of research in education as low (A1; 1.95).

Dr. Nathan explained that his seminar was intended to integrate teaching of skills with lecture-type activities. According to Dr. Nathan, during each component of his course, the level of *attention given to research will be high*. Dr. Nathan illustrated this with examples in which students were presented with assignments from the context of disciplinary research, for example, with research data from earlier research. Students were expected to use this existing data to train their analyzing skills. He stated explicitly that the focus would *not be on recent research or the research of the teacher*. An explicit learning goal in this course was to *stimulate the development of a research disposition* while working on the interpretation of data. The explanation Dr. Nathan gave about the mode of this course could be characterised as research-oriented. The student scores on the questionnaire showed that this course scored high on the scale 'attention to research' (B3; 3.77). Furthermore, according to the students, the development of their research disposition was stimulated to a moderately high degree (B3; 3.17). Students scored low on the scale of 'own research of the teacher' (A4; 2.12).

In her practical course, Dr. Susan planned to pay explicit *attention to bringing fun back into the practicals*. Dr. Susan aimed to achieve this through contextualization of the assignments, demonstration of novel experiments using materials from the laboratory, and description of the links with her own research experiences. Dr. Susan paid much *attention to explaining and showing how to do disciplinary research*. Dr. Susan's account of her course can be identified as research-oriented mode. All scores on the student questionnaire were moderately high, ranging from 3.82 (C) up to 2.52 (B2). Motivation for research scored moderately high (B3; 3.50), as did attention to research (A1; 3.55).

5.3.4 Teaching research-based courses

In a course with a research-based mode of the nexus, the emphasis is put on research processes, such as the gathering and analysis of data. Students are 'participants' in research activities, such as in research internships or open experiments during research practicals.

Dr. Adam explained that the focus of his course was *to prepare and conduct scientific observations* using methods commonly applied in the discipline. *Student participation in research activities was central*. Students made observations to solve a more or less open problem. An important teaching goal was that the development of students' *research disposition was provoked and stimulated*. Dr. Adam explicitly explained his awareness that each student (and each scholar) needed to develop his/her own research disposition. Therefore, he perceived a need to differentiate between students in order to provide each student with the correct feedback during the course. A research-based mode characterised this course best. Students scored moderately high on the scale 'attention to research' (A1; 3.62), and very low on the scale of 'own research of teacher' (A4; 1.87). The students in this course scored relatively low on the scale 'stimulating a research disposition' (B1; 2.70). Students scored the quality of teaching in this course high (C; 3.82).

According to Dr. Edward, many *research elements would be intertwined in this course*. The *students participated* in parts of Dr. Edward's *own research activities*. He aimed to give students the chance to practice with all kinds of experimental research practices in the discipline. His course resembled a research-based mode. The students (n=3) scored high on 'recent research' (A3; 4.40) and on 'own research' (A4; 4.38).

According to Dr. Paul, *research was an essential part of this course*. *Students participated* in the research of a PhD candidate studying under the supervision of Dr. Paul, and thus were working on *recent issues in the disciplinary research field*. Dr. Paul emphasised the relevance of the experiments to the students, explicitly stating the goal *to increase student motivation for research*. This description of Dr. Paul's resembled the research-based mode of the nexus. Students (n=2) scored high on all scales. The scale 'quality of teaching' (C; 3.55) scored lowest of all the scales of this courses; the rest of the scores were all above 3.80.

5.3.5 Congruence between teachers' intentions and students' perceptions

Table 5.5 depicts the average scores of the students' perceptions per teacher and per scale. Those elements to which the participating teachers explicitly referred in

their interviews as intentions for their courses and the elements which the teachers explicitly identified as not intended for the course are distinguished using separate symbols in Table 5.5. Congruent elements are marked with a plus sign, incongruent elements with a minus sign. Generally, the results presented in Table 5.5 reveal that 19 out of the 29 (66%) teachers' intentions related to the research-teaching nexus which were explicitly mentioned were in line with students' perceptions of the learning environment. Overall, based on the consistency rate presented in Table 5.5, consistency in teachers' intentions and students' perceptions can be discriminated. Three scales show consistency between teachers' intentions and students' perceptions, namely, 'participating in research' (A3; 4 out of 5), 'using research of teacher' (A4; 4 out of 5), and 'motivation for research' (B3; 3 out of 4). Two scales show low consistency, namely, 'becoming acquainted with recent research' (A2; 2 out of 4) and 'stimulation of research dispositions' (B1; 1 out of 4). The scale 'attentiveness to doing research' (A1; 5 out of 7) shows limited consistency. The scales which were, on average, rated highest by the students are 'motivation for research activities' (B3; 3.12) and 'quality of the learning environment' (C; 3.75). Notably, the two courses which scored highest on the scale 'quality of the learning environment' (C) are two research-led courses. Furthermore, the results on the scale 'participating in research' (A3) are notable, because all research-led courses show scores lower than average, while research-based courses show scores higher than average. This is in line with the 'student participation' versus 'student observation' dimension described by Healey (2005b), on which research-based education scores high on student participation in research activities, whereas research-led courses score high on student observation of research.

5.3.6 Aspects of scientific research disposition

In the interviews, the teachers were asked to explain which elements of students' research dispositions they intended to encourage. This provided in-depth information about teachers' intentions regarding issues related to the scale 'stimulation of research dispositions' (B1). In this section, we describe the aspects of research dispositions which teachers intended to emphasise in their courses. Furthermore, differences and similarities between the teachers in the four modes of the nexus are described. Various aspects were identified in the teachers' interviews, of which the 'inclination to criticize' was mentioned most often. The aspects of research disposition which the teachers intended to encourage among their students are presented in Table 5.4. Aspect 1 represents the first-mentioned aspect in the interview; aspect 2, the second. Most of the teachers referred to

two aspects; some only mentioned a single aspect of a research disposition. In Table 5.4, the aspects of research disposition to which the teachers referred in the interview are presented adjacent to the modes of the nexus. Below, five observations are described concerning the information about aspects of research disposition presented in Table 5.4. First, the aspect 'to innovate' was mentioned only by teachers with a research-oriented mode. Second, teachers with a research-based mode all mentioned at least one of the aspects 'to know' or 'to understand'. Third, note that the three teachers with a research-led mode all referred to the aspect 'to criticize'. Fourth, the aspect 'to share' was only present among teachers who taught courses in which emphasis was put on products of research (research-led and research-tutored mode). Finally, students' perceptions of the stimulation of the development of their research disposition (B1) were on average lowest among the group of teachers with a research-oriented mode of the nexus.

Table 5.4 Teachers' intentions to the development of students' research dispositions

Teacher	Mode of the nexus	Teachers' intention related to scientific research dispositions	
		Aspect 1 (inclination to)	Aspect 2 (inclination to)
Dr. Carlos	Led	Criticize	Share
Dr. Eliot	Led	Criticize	--
Dr. Tanya	Led	Criticize	--
Dr. Simon	Tutored	Share	Criticize
Dr. Charles	Oriented	Criticize	--
Dr. Howard	Oriented	Know	Criticize
Dr. Nathan	Oriented	Innovate	Know
Dr. Susan	Oriented	Innovate	Achieve
Dr. Adam	Based	Know	Achieve
Dr. Edward	Based	Achieve	Understand
Dr. Paul	Based	Know	Understand

Table 5.5 Teachers' intended mode and students' perceptions of the research intensiveness of the learning environment

Teacher	Mode of the nexus	Students' perceptions of the research intensiveness of learning environments							
		Attentiveness to doing research (A1)	Acquainting with recent research (A2)	Participating in research (A3)	Using research of teacher (A4)	Stimulating scientific research dispositions (B1)	Integration in a research community (B2)	Motivation for research activities (B3)	Quality of learning environment (C)
Dr. Carlos	Led	2.95 (1.32)	3.33 (1.27)	2.00 (.87)‡ +	2.25 (.50)	3.19 (.73)# -	2.67 (.01)	3.67 (.58)	4.20 (.35)
Dr. Eliot	Led	3.20 (.70)# -	3.79 (.75)# +	1.52 (.52)	2.94 (.96)# -	2.88 (.75)	3.00 (.90)	4.00 (.91)# +	3.56 (.81)
Dr. Tanya	Led	3.09 (.64)	3.60 (1.13)# +	1.70 (.71)‡ +	2.75 (1.41)	3.93 (.30)# +	2.50 (1.18)	4.50 (.24)	4.60 (.57)
Dr. Simon	Tutored	3.77 (.84)‡ -	3.90 (1.00)	2.20 (1.13)	3.75 (1.06)# +	3.43 (1.01)	3.33 (.94)	4.00 (.94)	3.80 (.42)
Dr. Charles	Oriented	2.57 (.48)	2.10 (.94)# -	2.83 (.59)	1.53 (.82)‡ +	2.76 (.52)	2.33 (.71)	3.04 (.79)# -	3.55 (.50)
Dr. Howard	Oriented	1.95 (.75)‡ +	2.10 (.72)	1.43 (.55)	1.35 (.45)	2.02 (.74)	1.76 (.75)	2.32 (1.00)	3.75 (.84)
Dr. Nathan	Oriented	3.95 (.47)# +	3.61 (.51)‡ -	2.31 (.92)	2.12 (.60)	3.17 (.67)# -	2.65 (.97)	3.77 (.70)	3.77 (.71)
Dr. Susan	Oriented	3.55 (.88)# +	3.20 (.73)	2.60 (1.01)	2.90 (.65)	2.87 (.57)	2.52 (1.02)	3.50 (.77)# +	3.82 (.45)
Dr. Adam	Based	3.62 (.70)	2.53 (.69)	2.20 (.72)# -	1.87 (.53)	2.70 (.35)# -	2.04 (.54)	3.11 (.44)	3.83 (.34)
Dr. Edward	Based	3.82 (.18)# +	3.87 (.58)	3.67 (.42)# +	3.83 (.88)# +	3.19 (.59)	3.11 (.84)	3.56 (.38)	3.77 (.32)
Dr. Paul	Based	4.14 (.19)# +	3.80 (.28)	4.40 (.57)# +	4.38 (.53)# +	3.93 (.30)	4.00 (.47)	3.83 (.24)# +	3.55 (.07)
Overall mean		**2.92 (1.07)**	**2.82 (1.01)**	**2.04 (.96)**	**2.04 (.98)**	**2.65 (.84)**	**2.30 (.94)**	**3.12 (1.05)**	**3.77 (.68)**
Consistency Rate		**5 out of 7**	**2 out of 4**	**4 out of 5**	**4 out of 5**	**1 out of 4**	**--**	**3 out of 4**	**--**

strongly part of intention of the teacher; ‡ not part of intention of the teacher

+ congruent; perceptions larger than 3.50 for elements being intended and smaller than 2.50 for elements which are not intended

- incongruent; perceptions smaller than 3.50 for elements being intended and larger than 2.50 for elements which are not intended

5.4 Conclusions and discussion

5.4.1 Congruence between teachers' intentions and students' perceptions

The central research aim was to establish associations between teachers' intentions and students' perceptions of the research intensiveness of university science courses. Generally, the results indicate that teachers' intentions are moderately congruent (66%) with students' perceptions of the research intensiveness of the learning environments. Teachers' intentions regarding the participation of students in research activities (A3) and using own research during the course (A4) were most often coherent with students' perceptions, while the stimulation of the development of research dispositions (B1) was least often coherent with students' perceptions. Participation in research activities and using research of the teacher during a course can both be categorised as tangible elements of the research-teaching nexus; stimulation of the development of students' research dispositions is an intangible element of the nexus. This result indicates that intentions about tangible elements are more coherent with students' perceptions than intangible elements. This can be explained in at least two ways. First, intangible elements are more difficult for students to perceive than are tangible elements. Second, intangible elements might be more difficult for teachers to emphasise. Therefore, teachers' intentions such as the stimulation of the development of research dispositions or the creation of an inquisitive atmosphere are more likely to be incongruent with students' perceptions than are teachers' intentions such as participation in research or using own research. In a recent study, it was found that students reported more learning outcomes on a dispositional level than explicitly intended by their teachers (Visser-Wijnveen, Van Driel, Van der Rijst, Verloop, & Visser, in press). The findings of that study and of the present study indicate that potential misunderstandings between teachers and students about intangible elements of the research-teaching nexus are latent. This suggests that misunderstandings about intangible elements of the research-teaching nexus are more likely to occur than misunderstandings about tangible elements of the nexus. It is advisable for teachers to keep in mind that such misunderstandings about the intangible elements might lead to unexpected and diffuse notions of the nature of scientific inquiry (cf. Abd-El-Khalick & Lederman, 2000).

These results also suggest that students perceive the development of their research dispositions less clearly during courses with a research-oriented mode than in courses with other modes of the nexus. A possible explanation is that when a student is following a course aimed at improving skills, it is more difficult for him or her to reflect on research processes or on research

dispositions. Reflection on research processes and dispositions might be stimulated best through observation of others, such as peers and experts, or through conducting authentic research in which the focus lies on the development of new knowledge, such as in courses with a research-based mode. In research-oriented courses the development of students' research dispositions might be stimulated through the creation of a critical and innovative atmosphere. Attention should be paid to the fact that when students are actively involved in the training of research skills the stimulation of the development of their research dispositions might not be perceived by them, although the teacher works on it constantly. Here, we assumed that both explicit attention of the teacher and awareness of the students are necessary for the development of appropriate research dispositions. Students' reflection on aspects of their own research dispositions can help them to focus on tacit elements of research, and can probably best be done before or after the assignments.

Some teacher intentions, which were perceived clearly by the students, were not mentioned by the teachers during the interviews as explicit intentions for the course. Dr. Simon, for example, did not explicitly intend to acquaint students with recent research (A2), nor did he explicitly intend to motivate students to pursue research (B3), but his students perceived both elements clearly in the course (A2, 3.90; B3, 4.00). Some teachers possibly did not consider it worthwhile to mention that specific intention during the interviews because they may have perceived it as obvious to have that intention, or that particular intention was not explicitly a learning goal or teaching goal for the teacher, but a thing he/she did implicitly pay attention to.

5.4.2 Limitations and suggestions for further research

Student scores on the questionnaire depend not only on students' perceptions, but also on their expectations (Könings, 2007). This might give an explanation of the result that students in a research-led course perceived the quality of the course and their motivation for research very clearly, while we expect that a course in which the teacher transmits knowledge by direct instruction would not always stimulate motivation for research, nor be considered a high-quality learning environment. It is possible that the students had low expectations of the quality and the stimulation of their motivation for research, but were pleasantly surprised by the actual design of the course. Thus, the results of this study can not be used to compare between cases, but they may provide information about associations within cases. Furthermore, it might be interesting, in future research, to relate teachers' intentions to a combined measurement of students'

perceptions and expectations, in order to gain a greater understanding of possible associations between teachers' intentions and overall student experiences.

Students' perceptions of different kinds of learning environments were investigated in this study. The results suggest that there are differences and similarities in students' perceptions of learning environments. The evaluation of students' perceptions of the constructed learning environments can be an effective tool to stimulate teachers to reflect on their own teaching practices. The questionnaire used in this study might be used as an evaluation tool for teachers to become aware of students' perceptions of the constructed learning environment, and specifically to become aware of students' perception of research activities in their courses.

The results of this study show that teachers' intentions related to tangible elements of the nexus are relatively more coherent with students' perceptions than teachers' intentions regarding intangible elements of the nexus. This invites us to stimulate awareness among academics that the development of students' research dispositions, as an intangible element of the research-teaching nexus, needs explicit attention if we want students to perceive and appreciate research dispositions in their studies and later in their careers.