Student engagement in research in medical education

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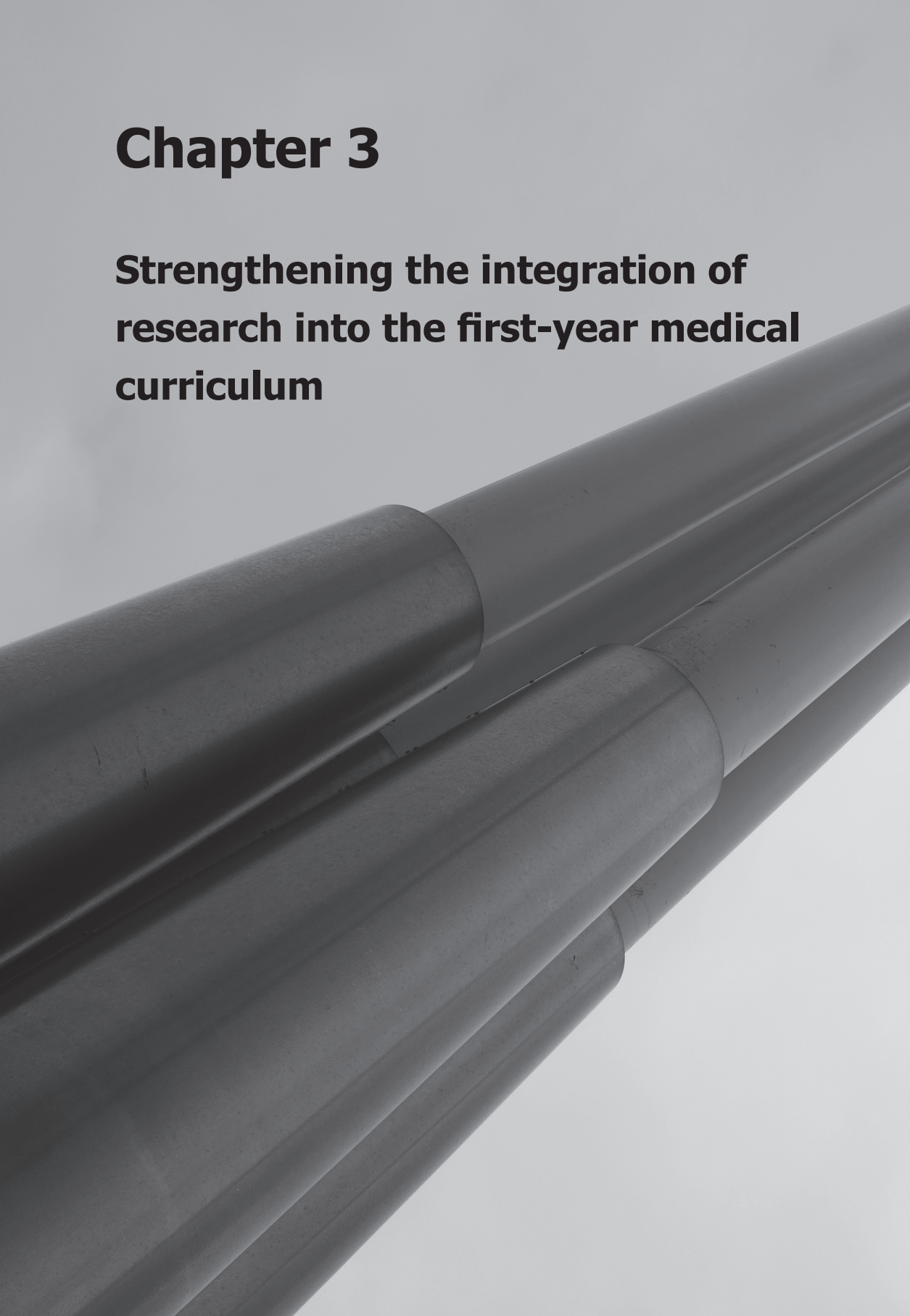
Chapter 3

Strengthening the integration of research into the first-year medical curriculum



3. Strengthening the integration of research into the first-year medical curriculum.

The integration of research into the undergraduate study programme is important in order for medical students to understand and value research for their later clinical practice. Therefore, attempts are being made to strengthen the integration of research into teaching during the first undergraduate year and beyond. However, first-year students may interpret attempts made to strengthen research integration differently than expected by their teachers. This difference might be explained by student beliefs regarding learning and research as well as student perceptions of the learning environment. In general, student perceptions of the learning environment play a pivotal role in fostering student learning outcomes. This study aims to determine whether a curriculum change intended to promote the integration of research into the study programme fosters student learning outcomes and student perceptions of research integrated into teaching. To serve this purpose, three subsequent cohorts of first-year students were compared, one before and two after a curriculum change. Learning outcomes of these students (n = 921) were measured using their scores on a national progress test and assessments of a sample of 100 research reports produced as part of the first-year student research projects. Some 746 students filled out the Student Perceptions of Research Integration Questionnaire. The findings suggest that the learning outcomes of these students, that is, their scores on research related test items of the progress test and the quality of research reports, were better than those of students prior to the curriculum change. Moreover, the students perceived a stronger research focus in the curriculum.

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3.1 Introduction

The promotion of undergraduate students' understanding of research is an important aim of medical education worldwide (Association of American Medical Colleges [AAMC], 1998; CanMeds, 2015; GMC, 2015). It puts emphasis on strengthening the integration of research into teaching in undergraduate medical education, for example, through curriculum interventions to promote students' understanding of research (Mullan, Weston, Rich, & McLennan, 2014; Pruskil, Burgwinkel, Georg, Keil, & Kiessling, 2009). Medical students consider the integration of research into their study programme to stimulate their learning process (Murdoch-Eaton, et al., 2010), although such students might be less enthusiastic about strengthening that research integration by means of conducting their own research projects. Indeed, previous studies have emphasised students concerns about research endeavours that could delay the completion of their medical education (Funston, et al., 2016; Siemens, Punnen, Wong, & Kanji, 2010). Medical teachers are therefore challenged to explicate research in all their teaching in order for students to understand and value research in relation to routine clinical practice, not just for physician-scientists (Laidlaw, Aiton, Struthers, & Guild, 2012; Ribeiro, Severo, Pereira, & Ferreira, 2015). The aim of this study is to determine the effects of strengthening research integration into teaching on student learning outcomes and student perceptions of research within undergraduate education among large cohorts of students. The term 'research integration' is used to refer to all learning activities in which the fostering of student engagement in research findings and research processes is an essential part of first-year undergraduate courses in the medical domain (cf. Healey & Jenkins, 2009).

Several studies already highlighted the importance of strong research integration for student learning. Research integration, for example in students' research projects, traditionally takes place towards the end of the undergraduate medical study programme (de Oliveira, Luz, Saraiva, & Alvez, 2011; Oliveira, et al., 2013; Siemens, et al., 2010). First-year students in particular might find it difficult to experience aspects of research in courses within their undergraduate

education in a way that influences their learning outcomes (Burgoyne, O'Flynn, & Boylan, 2010; Oliveira, et al., 2013). Additionally, teachers may feel that first-year undergraduates in higher education are not yet 'open' to research (Zamorski, 2002). Furthermore, first-year students see themselves as an audience for research rather than considering themselves to be involved in knowledge production (Jenkins, Blackman, Lindsay, & Paton-Saltzberg, 1998). First-year students have positive expectations about doing research later in their degree (Smith & Rust, 2007). However, students also report disadvantages of research being integrated into teaching, such as staff needing to overcome their own challenges when dealing with teaching and research responsibilities (Healey, Jordan, Pell, & Short, 2010). Thus, first-year students may interpret the efforts made by teachers to explicate research differently to what their teachers intended (e.g., van der Rijst, Visser-Wijnveen, Verloop, & van Driel, 2013). The present study therefore compares cohorts of first-year students when research is more prominently incorporated into undergraduate courses using student perceptions of research integration and student learning outcomes as concepts.

The integration of research into undergraduate courses can take different forms based on two dimensions (Healey & Jenkins, 2009). The first dimension concerns the focus of the research elements that are integrated into courses and it extends from research processes (e.g., data collection and analysis in regular courses) to the research content (e.g., focus on student understanding of research findings through coursework). The second dimension describes the extent to which students are actively engaged in research through their courses and it extends from students involved as an audience for research to students involved as participants in research in the sense that students engage in research activities during their courses. These dimensions result in four basic ways in research can be integrated into courses (see Figure 3.1).

It has previously been argued that these different ways to integrate research complement each other in order to promote student perceptions of research and perceived student learning outcomes (Healey & Jenkins, 2009).

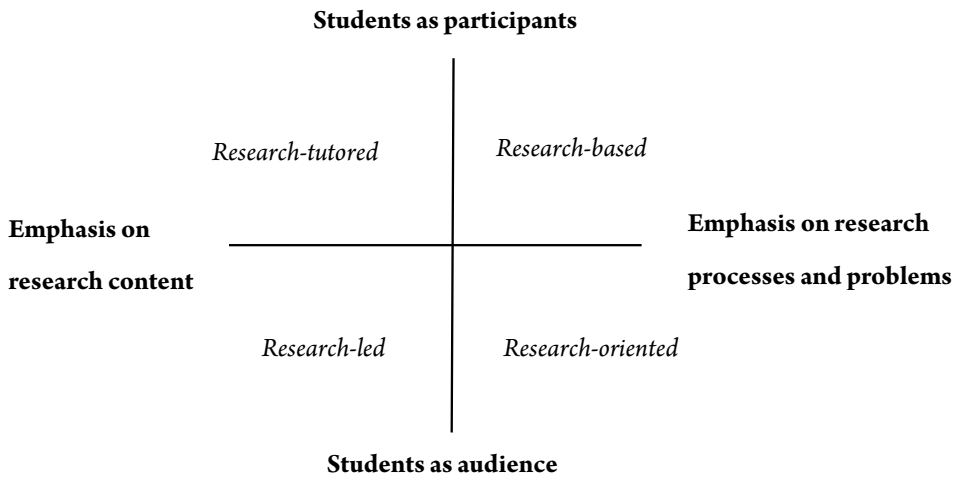

Figure 3.1. Two dimensions describing the integration of research into undergraduate courses (Healey, 2005).

3.1.1 Relationships between student learning outcomes, beliefs and perceptions

Constructivist models of student learning in higher education from the field of educational psychology show that student perceptions of the learning environment play a pivotal role in promoting their learning outcomes (Biggs, 1985; Prosser & Trigwell, 1999). Student perceptions can provide a valid and reliable image of the learning environment, since students have extensive experience of making observations during their school careers (Marsh & Roche, 1997; Spooren, Brockx, & Mortelmans, 2013). Positive perceptions on the part of students directly influence their level of achievement, including learning outcomes such as skill performance and motivation for learning (Lizzio, Wilson, & Simons, 2002). These models of student learning suggest that the relationships between learning outcomes and student perceptions of teaching are reciprocal. Thus student perceptions of the effectiveness of teaching facilitate effective learning and vice versa (Ramsden, 1991), even during the first undergraduate year (Prosser & Trigwell, 2014).

Student perceptions of the learning environment are related to student beliefs regarding learning. Such beliefs are generally referred to as a set of (partly implicit) suppositions, or as a lens through which students interpret the world, and they are considered to remain relatively stable over time and courses (Pajares, 1992). In addition to student beliefs, various elements of the learning environment itself and their prior learning experiences also influence student perceptions of the learning environment (e.g., Ashwin & Trigwell, 2012). In the present study we were primarily interested in student learning outcomes and student perceptions of research. However, student beliefs were still taken into account in order to allow our results to be interpreted sensibly. This was particular true in the case of explaining student learning outcomes and perceptions by means of changes in the learning environment.

Undergraduate medical students in their penultimate year of study might hold a belief that research is only of limited value to their learning process during clinical rotations, although their perceptions of research could change after participating in a research project (cf. Murdoch-Eaton, et al., 2010). Findings from a recent review study suggest that students, after completing a research experience, recognise the importance of research for their future career path (Chang & Ramnanan, 2015). In terms of their learning outcomes differences were found among students' interpretations of what research entails and the skills perceived to be involved in research (Bierer, Prayson, & Dannefer, 2015; Murdoch-Eaton, et al., 2010). Undergraduate medical students' interpretations of research may be focused on hypothesis testing, knowledge production, data collection and discovering new things (Burgoyne, et al., 2010). Extending the approach of previous studies, this study focusses on conceptually related variables (i.e., student learning outcomes, beliefs regarding the value of research for learning and student perceptions of research) in the context of strengthening research integration from the first-year onwards.

Two research questions are addressed in this study. First, what is the influence of a curriculum change placing a strong emphasis on research integration into the first-year medical study programme on student learning outcomes, especially student products and test scores within the domain of research? Second, what is the influence of a curriculum change placing a strong emphasis on research integration into the first-year medical study programme on student perceptions of research in teaching and on student beliefs regarding the relevance of research for practice and learning?

3.2 Educational context

Our study was conducted at the Leiden University Medical Center (LUMC) in the Netherlands. Staff members at the LUMC are responsible for patient care, research and teaching. Every academic year, some 330 students start studying medicine in the LUMC. The undergraduate medical programme was structured in a two-cycle model (Patrício & Harden, 2010). A weighted lottery procedure based on students' grade point average (GPA) in secondary education was used to govern first-year student admission for all cohorts included in this study. Students with a high GPA are more likely to be admitted to the programme.

A curriculum change was implemented in the first cycle from the 2012-2013 academic year onwards. A timeline of the curriculum change is presented in Figure 3.2. Prior to the 2012-2013 academic year, the first-year curriculum (i.e., the previous curriculum) was predominantly based on theoretical classes augmented by learning activities performed in small groups. The aim of the curriculum change was to strengthen the integration of research into the undergraduate programme as was described in Chapter 2. The changes made to the curriculum design were informed by the integration continuum, which features, full integration at one end and discipline-based education at the other (Harden, 2000). In this study, the previous curriculum is considered to be 'harmonised' in the sense that the teachers consulted each other and communicated about their courses. However, the changed curriculum can be classified as 'multi-disciplinary', since clearly identified subjects were brought together in a single course that featured an integrated theme, with the aim being to provide authentic learning experiences (Harden & Laidlaw, 2012; also see Chapter 2). In the changed curriculum teachers from the basic sciences and clinical disciplines were brought together

to collaboratively develop courses. The duration of the courses was between two and five weeks and the courses were developed within separate disciplines. The assessment of students took place at the end of a course mainly by means of a multiple-choice question examination. After the 2012-2013 academic year the changed curriculum (version 1.0) was evaluated by both students and teachers. As a result, minimal adaptations were made in order to improve student learning experiences, for instance, improving the spread of the study load (version 1.1). The previous and changed curricula were developed according to the Dutch Blueprint (NFU, 2009). This study was designed to allow for a comparison between student learning outcomes within a curriculum that uses strategies to foster harmonisation and a curriculum aiming to promote multi-disciplinary strategies in order to strengthen research integration.

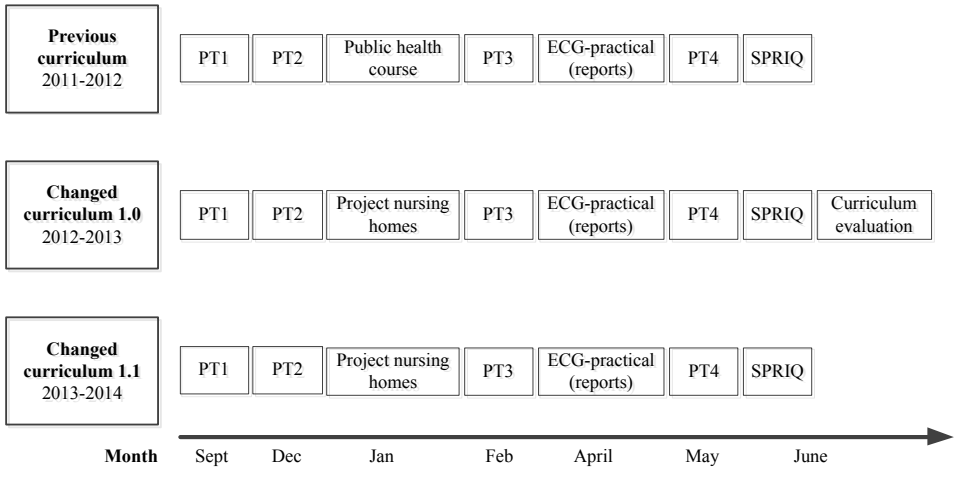

Figure 3.2. Timeline of the curriculum change including progress tests (PT), student research activities and the Student Perception of Research Integration Questionnaire (SPRIQ).

3.2.1 Fostering the integration of research into the study programme

In terms of research integration, the curriculum change aimed to promote the authenticity of student learning experiences (see Chapter 2). In particular, a classical three-week course on public health, epidemiology and biostatistics contained within the previous curriculum was replaced by a small student research project for all students in the context of an early clinical experience in nursing homes (cf. Dekker, et al., 2009) (see Figure 3.2). A more detailed description of this research project can be found in section 2.2. All the students were actively involved as participants in research, since they conducted their own research project as a learning activity (cf. Healey & Jenkins, 2009).

In both curricula, the students also participated in a practical in April in which they collected electrocardiographs (ECGs) of their peers, formulated a research question, analysed the data and present findings. The emphasis was on the promotion of student understanding of study designs, statistics as well as written and oral presentation of findings. The students also wrote a short research report during a small-group session. The ECG-project had been developed to incorporate research more explicitly, so it was maintained with only minimal adaptations. Student instruction in this course was extended by one small-group session involving peer feedback on academic writing.

In addition, all the teachers were encouraged by a curriculum committee to explicate the links between research and clinical practice within their courses where possible (e.g., Laidlaw, et al., 2012). To that end, the curriculum developers discussed the students' research projects with all the teachers. These discussions compelled teachers to explicate their ideas for strengthening research integration appropriate to their field and course.

3.3 Methods

3.3.1 Data collection and instruments

The cognitive learning goals of the medical programme were tested four times a year using a national progress test (PT) (Muijtjens, Schuwirth, Cohen-

Schotanus, Thoben, & van der Vleuten, 2008). In the Netherlands, staff members from five universities participate in writing test items that cover knowledge across all disciplines and domains relevant to the medical degree. The first PT took place in September, the second PT in December, the third PT in February and the final PT in May (see Figure 3.2). The aim of the PT is to determine the growth of individual student knowledge longitudinally, and hence the PT contributes to more reliable and valid decision making concerning future competence or the retention of knowledge (e.g., Schuwirth & van der Vleuten, 2012). The students' scores for the third (March) and fourth (May) PT during the first year of study were collected. Nine of the 200 items in total per PT reflected the students' knowledge about scientific research and methods and they were assessed in closed format ('true', 'false', 'do not know'). The 'do not know' option is scored as a neutral 0, which is preferred over negative marking in the PT, since this option allows students to avoid a penalty for guessing (McHarg, et al., 2005; Muijtjens, Mameren, Hoogenboom, Evers, & van der Vleuten, 1999). Students scored +1 point for every correct answer, -1 for every incorrect answer and 0 points when they answered 'do not know'. The scores for the PTs were converted to a scale ranging from 0 to 100 for further analysis.

In the ECG-practical, the students wrote an extended abstract as a research report. The reports were rated using a rubric developed especially for this study. The raters were trained during the rubric's development process so as to enable informed decisions to be made about the criteria and descriptors that adequately capture the key aspects of students' performance (e.g., Cook & Hatala, 2016). Two batches of 50 reports were randomly selected (previous and changed curriculum) and they were all blindly and anonymously assessed by six trained raters (an educationalist, an epidemiologist, a paediatrician, a physiologist and two third-year students) on using a grading rubric designed for this study. The rubrics contained 11 criteria and three descriptors (range 0-22) regarding (1) consistency across the introduction, method, results and discussion and (2) the structural characteristics of the text in order to assess the written presentation of the students' research findings (see Appendix 3). The intraclass correlation coefficient (ICC) for the average measure using absolute agreement with six fixed raters was .81, which suggests good interrater reliability (Streiner & Norman, 1995). The average measure was used, since (1) the raters were a random sample of all possible raters and (2) the reports were randomly selected (Shrout & Fleiss, 1979).

3.3.1.1 Student beliefs and perceptions

To measure student perceptions of research integration and student beliefs regarding research the researcher administered an adapted version of the Student Perception of Research Integration Questionnaire (SPRIQ) (see section 2.3.3). The scales include: (1) critical reflection on how research results are produced; (2) student participation as a researcher in learning activities; (3) familiarity with current research done by staff; (4) interest and motivation for research; (5) beliefs regarding the value of research for their learning; (6) beliefs regarding the value of research for clinical practice and (7) perceived quality of the learning environment. All 30 items were answered on a 5-point Likert scale. Table 3.1 presents the scales, reliability and sample items of the version of SPRIQ that was used in this study with this sample.

Table 3.1. Scales, reliability and sample items of the Student Perception of Research Integration Questionnaire for first-year students following the previous and changed curriculum

Scales	N items	Sample items during this academic year…	α*
First-year student perceptions			
Critical reflection on research	4	… attention was paid to research methods.	.63-.75
Participation in research	5	… as a student I felt involved in research.	.82-.85
Familiarity with current research	5	… I became familiar with the research carried out by my teachers.	.72-.79
Motivation for research	4	… I became enthusiastic about research in medicine.	.81-.83
Other			
Beliefs regarding the value of research for practice	6	Scientific skills are important for being a doctor.	.84-.88
Beliefs regarding the value of research for learning	3	… my learning is stimulated when education is grounded in research.	.80-.85
Quality of learning environment	3	… the teachers carried out their instruction adequately.	.69-.75

*Cronbach's alpha varied slightly per year of data collection; lowest and highest are reported indicating acceptable to strong internal consistency of scales (Cohen, 1998).

3.3.2 Participants

All first-year students who began their studies following the previous or the changed curriculum 1.0 and 1.1 were invited to participate in this cohort study. Two groups of students who followed the changed curriculum were included to be able to check for cohort effects. Data were collected during lectures from May to June of every academic year (see Figure 3.2). We distributed hardcopy questionnaires to all students who attended the lectures. They were asked to fill out the questionnaire for all courses taken up to that point. They were asked for permission for their unique student identification number to be used, so that we could send the questionnaire to the students not present at the lecture. A reminder was sent by e-mail to those students who did not respond to the initial invitation. Ethical approval was granted by the LUMC Research Ethics Committee.

3.3.3 Analysis

3.3.3.1 Progress tests

The mean score for the items about scientific research and methods on PT1 and PT2 prior to the student research projects in the nursing homes was calculated per curriculum, as well as for PT3 and PT4 after this project. We compared the mean scores for the items using independent t-tests (changed curriculum 1.0-previous curriculum; changed curriculum 1.1-previous curriculum). In addition, we used linear regression to adjust for the mean score of items about scientific research and methods in PT1 and PT2 before the student research project. In a separate linear regression analysis, we adjusted for the mean overall score on PT3 and PT4.

3.3.3.2 Research reports

The mean score per report and over all reports and raters was calculated. Thereafter, the reports were decoded, which indicated whether a particular report was written as part of the previous curriculum or the changed curriculum. Then the reports were divided based on the two curricula. After that we compared the scores per curriculum, for all the raters and reports using an independent t-test.

3.3.3.3 SPRIQ

The means for every scale of the SPRIQ were calculated for all the cohorts. After that, scale means per curriculum were compared using independent t-tests (changed curriculum 1.0-previous curriculum; changed curriculum 1.1-previous curriculum). A confidence interval of 95% was applied for all t-tests.

3.4 Results

3.4.1 Student learning outcomes

The student scores for the research-related items of PT1 and PT2 were lower for the changed curriculum in 2012 (mean difference -5.39 (95% CI [-7.20; -3.60]), while the mean scores of the students for the research related items of PT1 and PT2 were higher for the changed curriculum in 2013 (mean difference 4.26 (95% CI [2.33; 6.19])). The mean score for the research-related items of PT3 and PT4 for the changed curriculum in 2012 was significantly higher when compared to that for the previous curriculum (Table 3.2). After correcting for the corresponding mean score of research-related items of PT1 and PT2 the adjusted difference was 14.73 (95% CI [12.29, 17.17]). When controlling for the student mean scores for all the items of PT3 and PT4 the difference between the previous and changed curriculum 1.0 was 9.62 (95% CI [7.45, 11.78]). In the changed curriculum 1.1 the mean score on the research-related items of PT3 and PT4 was also significantly higher when compared to the previous curriculum (Table 3.2). This difference remained after controlling for student scores on research-related items of PT1 and PT2 (adjusted difference 15.98; 95% CI [13.48, 18.48]). After controlling for student scores for all the items of PT3 and PT4 the effects were not materially different (adjusted difference 14.55; 95% CI [12.31, 16.77]). With regards to the student research reports, a significant difference was found between the previous curriculum and the changed curriculum 1.1 in favour of the changed curriculum (difference 5.90; 95% CI [4.89, 6.91].

Table 3.2. Mean scores for student learning outcomes and scale means on the Student Perception of Research Integration Questionnaire per cohort (five-point Likert scale) before and after the curriculum change

Scales	Previous curriculum Mean (sd)	Changed curriculum 1.0 Mean (sd)	Changed curriculum 1.1 Mean (sd)
Student perceptions			
Critical reflection	2.98 (.66)	3.24 (.61)*	3.44 (.63)*
Participation in research	1.94 (.69)	2.20 (.72)*	2.44 (.71)*
Familiarity with current research	2.65 (.68)	3.02 (.72)*	3.09 (.62)*
Motivation for research	2.71 (.78)	2.97 (.81)*	3.11 (.77)*
Other			
Beliefs on value of research for practice	3.64 (.67)	3.56 (.76)	3.75 (.52)
Beliefs on value of research for learning	2.99 (.81)	2.96 (.84)	3.21 (.77)*
Quality learning environment	3.80 (.51)	3.76 (.61)	3.75 (.52)
Student learning outcomes			
Student research reports	8.93 (2.77)	No data	14.83 (2.31)*
Research related progress test (PT) items (PT1 & PT2)	14.25 (12.32)	8.85 (11.78)	18.51 (13.10)*
Research related progress test (PT) items (PT3 & PT4)	16.47 (14.26)	28.93 (16.21)*	34.41 (17.29)*

*indicates this scale mean is higher than in the previous curriculum (t-test; p≤.05).

3.4.2 Student beliefs and perceptions

In total, some 746 first-year students completed the SPRIQ (response rate 75.4%). A vast majority of the respondents had begun studying medicine as their first degree (n = 692). Table 3.3 provides an overview of the data collection periods and characteristics of the respondent group. The majority of the participating students was female, which indicates that the sample is representative of the medical student population (e.g., van der Velden, Hingstman, Heiligers, & Hansen, 2008).

Table 3.3. Characteristics of data collection and cohorts of first-year students

Curriculum	Data collection	$N_{respondents}$	Female	Response rate	Average age (yrs)
Previous	May/June 2012	261	187 (71.6%)	85.9%	19.7
Changed 1.0	May/June 2013	248	147 (59.3%)	75.2%	19.4
Changed 1.1	May/June 2014	237	149 (70.6%)	62.2%	19.5

Table 3.2 shows the scale means of the SPRIQ for the previous curriculum in comparison to those of the two groups in the changed curriculum. The abbreviations indicate the scale names. The scores on the perception scales 'critical reflection', 'participation', 'familiarity' and 'motivation' are significantly higher in the changed curriculum 1.0 and 1.1 than for the previous curriculum. Further, the scale means on the perception scales are the highest for the changed curriculum 1.1. With regards to beliefs regarding the value of research to future practice and the perceived quality of the learning environment, no differences were found between curricula. When following the changed curriculum 1.1 students held a significantly stronger belief about the value of research for their learning than in the earlier curricula. 'Critical reflection on research' was experienced the most, then 'familiarity with current research' and 'motivation for research' in all three groups. Perception scores for 'participation in research' were the lowest of four scales in both curricula, although students felt significantly more involved as participants in research through the learning activities when following the changed curriculum.

3.5 Discussion

The findings of this study suggest that strengthening research integration has a positive effect on research-related first-year student learning outcomes, especially on the research-related items of a national progress test and research reports written during a student research project. The results indicate that first-year medical students recognised a stronger emphasis on research within their courses after a curriculum change that was intended to promote student engagement in research. The first-year students tended to believe that research is important for their future careers in clinical practice. In sum, the findings suggest that the changed curriculum seemed to improve students' perceptions of research integration, although it did not seem to affect their beliefs regarding the value of research.

The curriculum change described in this study consisted of interventions with regard to assessment, collaboration between disciplines in teaching and the duration of courses in order for students to benefit from an emphasis on strengthening the integration of research and teaching. Since the study design was observational in nature, causal conclusions in relation to the curriculum change and student learning outcomes must be drawn with caution. Nevertheless, this study attempted to answer the call made in comparative curriculum studies to use the best possible comparison group (cf. Pruskil, et al., 2009). The data used in this study reflect first-year student learning outcomes and student perceptions of research integration. In higher education research in general it is argued that the quality of student learning outcomes depends on various factors related to the quality of student learning as a process, including students' prior learning experiences, student perceptions of the learning environment and their approaches to learning (e.g., Prosser & Trigwell, 2014). The different approaches to learning indicate whether students focus on, for example, transmission, reproduction or production of knowledge (Prosser & Trigwell, 2014). The present study, therefore, contributes to the quality of student learning within medical education by improving students' research knowledge through learning activities within the undergraduate programme (e.g., Laursen, 2015). The findings of this study are based on high response rates, validated questionnaires and two types of learning outcomes. Most importantly, our findings can be explained by the conceptual relationships between student learning outcomes, student beliefs regarding the value of research for learning and student perceptions of research integrated into courses (Pajares, 1992; Prosser & Trigwell, 2014).

The students performed better on the research-related items of a national progress test and on written student research reports after the curriculum change. An explanation for this is the fact that the students in the changed curriculum were actively engaged in an authentic student research project prior to writing the reports and doing the progress tests (cf. Chapter 2). In the learning process in general student learning outcomes are influenced by factors such as student perceptions of teaching, as well as student motivation and values (Biggs, 1985; Prosser and Trigwell, 1999). In that sense the learning outcomes measured in this study were closely related to the learning process whereas previous studies concerning research integration and medical student learning might be more removed from the students' actual learning process. In a recent systematic literature review, Chang and Ramnanan (2015) suggest that previous attempts made to improve student learning and research-related outcomes were mainly informed by student perceptions of research and long-term research outcomes such as presentations at conferences and peer-reviewed publications. This might raise questions about the appropriateness of the variables used in medical education research into research integration, for example, research output, for informing curriculum decision making and to improve the quality of student learning.

Teachers may feel that first-year students might not yet be open to research (Zamorski, 2002), which could be the case for undergraduate medical students in general (Burgoyne et al. 2010; Murdoch-Eaton, et al., 2010). However, our findings suggest that students do recognise research integration and, more importantly, that a curriculum change including a first-year student research project can promote student perceptions of research during the first undergraduate year of medical education. Students recognise research in courses in several ways according to the scales used in the SPRIQ. The results show that, although student perceptions of research increased on all the scales after the curriculum change, participation in research was experienced to the least extent and critical reflection on research the most. This indicates that the perceived ways in which research is actively included in student learning are complementary. Teachers should hence be encouraged to use a range of modes in order to actively include research even within the first-year of university education.

Small differences were found between student beliefs regarding research before and after the curriculum change. The relatively stable nature of beliefs can provide an explanation for this (Pajares, 1992). Students already tend to believe that research is important for physicians' practice when they begin their medical education. Despite the nature of beliefs, this indicates that the differences found in the learning outcomes and student perceptions in our study can be explained by changes in the learning environment (e.g., Ashwin & Trigwell, 2012).

Future studies are needed to provide further insight into student learning processes during courses or projects in which research is strongly integrated in order to improve the quality of student learning about research. Future studies in medical education research might benefit from careful consideration of variables and designs used to foster high-quality learning outcomes in medical education research into research integration. For example, by focusing on relations between student perceptions of research in teaching, the way students approach learning (i.e., knowledge transmission, reproduction, production) and student learning outcomes (e.g., Prosser & Trigwell, 2014; van der Rijst, 2017).

3.6 Conclusions

This study was conducted in order to improve our understanding of the relation between student learning outcomes, beliefs regarding the value of research for student learning and student perceptions of research integrated into the study programme by investigating first-year student learning in the context of a curriculum change. The first-year students who followed the changed curriculum performed better on the research-related learning outcomes in a national progress test as well as in writing research reports as part of a student research project. Students in a changed curriculum, intended to strengthen research integration, recognised a stronger emphasis on (1) critical reflection on research, (2) participation in research activities, (3) familiarity with research done by the staff and (4) being motivated for research in medical education. Students tended to exhibit a strong belief in the value of research for their future clinical

practice. The implications of this study can inform curriculum decisions about integrating research into courses using multi-disciplinary strategies in order to foster research integration (cf. Harden & Laidlaw, 2012). In sum, strengthening the integration of research into undergraduate courses is feasible in a limited amount of curriculum time, and can lead to enhanced student perceptions and associated learning outcomes. The findings of this study indicate that student beliefs regarding the value of research are less fluent when compared to student perceptions of research and learning outcomes in the domain of research. This study contributes to an emerging body of knowledge about improving students' research knowledge through student engagement in research as a pedagogy, that is, through learning activities within the undergraduate curriculum.