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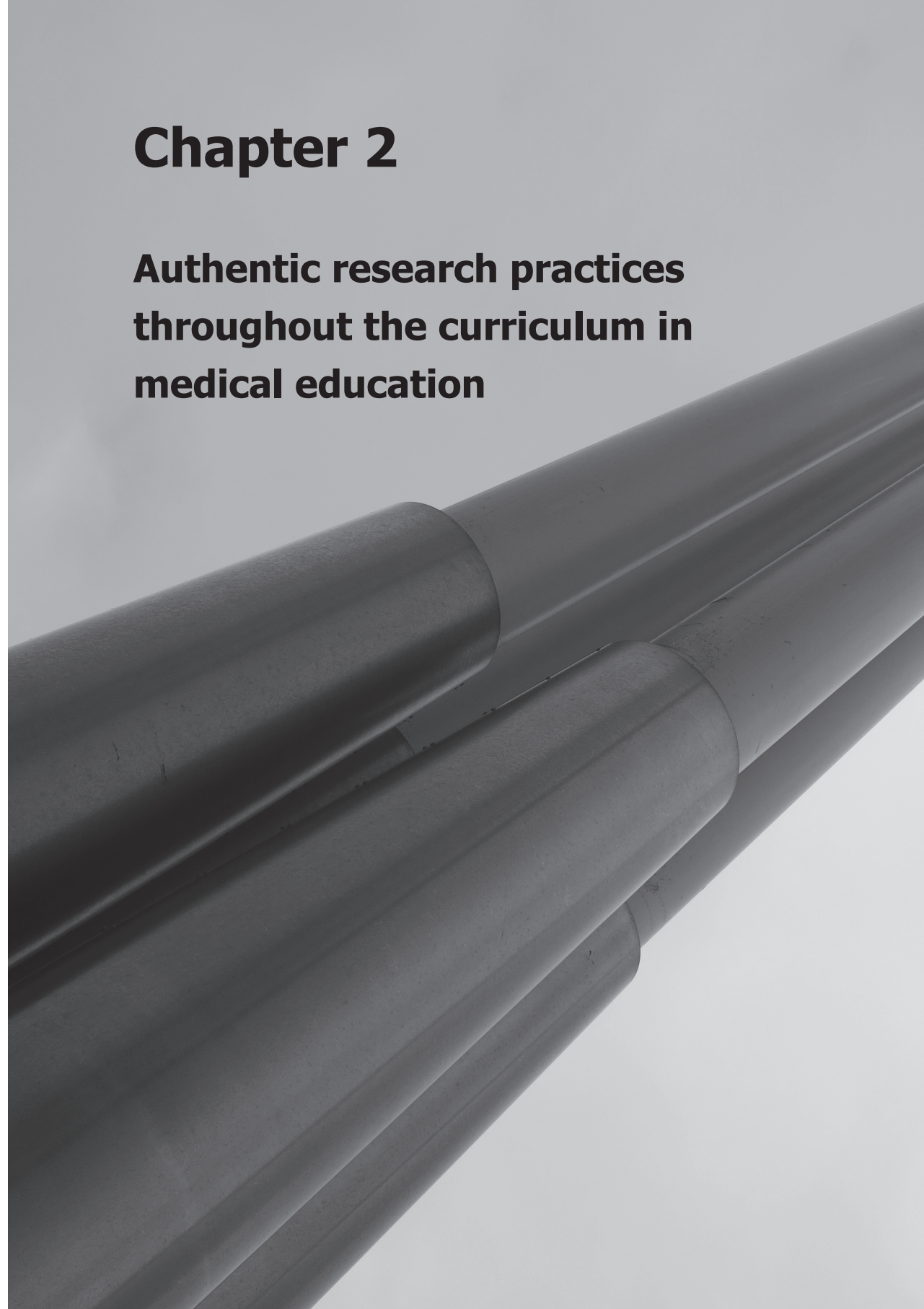
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Chapter 2

Authentic research practices throughout the curriculum in medical education

2. Authentic research practices throughout the curriculum in medical education.

Interest in integrating research into university teaching has been growing in higher education worldwide in recent years. Findings from previous studies indicate that opportunities for students to participate in research practices can promote student beliefs regarding the importance of research within their field. Yet, making research accessible to students is not a straightforward process. This study aims to assess the influence of authentic research practices on medical undergraduates' perceptions of research and their beliefs regarding the relevance of research to professional practice. A longitudinal study was conducted in the context of a curriculum change that aimed to strengthen the integration of research into teaching. To investigate the influence of authentic research practices, three successive cohorts of undergraduates participated in this study. In total, 941 students completed the Student Perceptions of Research Questionnaire. Our findings suggest that research practices within professional contexts not only promote student participation in research and motivation for research, but also foster the belief that research is relevant for learning. It is suggested that in order to foster student learning about research in hard-applied disciplines, it is beneficial to strengthen the integration of research, teaching and professional practice. Furthermore, we highlight the implications for further research as well as teaching practice aimed at fostering student beliefs about the value of research for professional practice.

2.1 Introduction

Interest in integrating research into study programmes has been growing in university education internationally in the recent decades (Brew & Mantai, 2017; Healey & Jenkins, 2009; Visser-Wijnveen, van der Rijst, & van Driel, 2016). A recent trend towards student involvement in research through learning activities has placed an emphasis on those activities that enable students to experience research within their field (Brew & Mantai, 2017; Healey & Jenkins, 2009; Hu, van der Rijst, van Veen, & Verloop, 2014). Findings from previous studies suggest that opportunities for students to engage in authentic research practices can, under conditions of good teaching, promote student reflections on the meaning of knowledge construction in their field (van der Rijst, 2017; Visser-Wijnveen, et al. 2012; Wald & Harland, 2017). Yet, engaging students in authentic research practices through undergraduate teaching in such a way as to make research visible and accessible to students is not that unambiguous (Brew & Mantai, 2017; van der Rijst, Visser-Wijnveen, van Driel, & Verloop, 2013; Visser-Wijnveen, et al. 2012). Our study hence aims to further our understanding of student perceptions of research and their beliefs regarding the relevance of research to learning and practice in relation to authentic research practices within the learning environment. A better understanding of student perceptions of research, beliefs and authentic research practices is important for those who aim to strengthen the role of research in teaching and learning. The results from this study can inform initiatives for fostering research-teaching integration in order to promote student learning within higher education institutes.

2.1.1 Authentic research practices
In this study the term 'authentic research practices' is used to indicate that learning activities reflect research practices within the discipline and to indicate that open-ended learning activities incorporating research are placed within the context of future use of research in professional practice. Examples of authentic research practices can be found, for instance, in science education, indicating that such learning activities are closely aligned with the way scientists do their work as

opposed to strongly guided science laboratory exercises (Crawford, 2015, p. 113). The term 'authentic research practices' was chosen to emphasise how research incorporated in learning activities mirrors the 'real world', especifically the way in which research is used in professional settings (Herrington & Herrington, 2006; Wald & Harland, 2017). Authentic research practices as defined in this study are different from pedagogies incorporating research into student learning, for example, problem-based learning and inquiry-based learning, which instead focus on an inquiry-based approach to knowledge application and exploration of subject matter (e.g., Savin-Baden, 2000; Spronken-Smith, Walker, Batchelor, O'Steen, & Angelo, 2012).

Our study was conducted within the medical discipline. Most medical students go on to work as practitioners rather than scientists; therefore, authentic research practices are important for fostering student learning about the use of research in clinical practice (e.g., CanMeds, 2015; GMC, 2015; NFU, 2008). The medical discipline was chosen as an example of a hard-applied discipline, in which knowledge construction can be characterised by a relatively high consensus concerning paradigms, research content and methods (Becher & Trowler, 2001; Biglan, 1973). Furthermore, medical research mainly focuses on applied, patient-related problems (Becher & Trowler, 2001; Biglan, 1973). The term 'authentic research practices' is hence used in this study to indicate that the research practices are intended to promote student learning and reflect ways in which knowledge is produced and communicated within professional settings in medicine.

Previous studies into authentic learning, such as those conducted within communities of practice, have indicated that learning activities refer to the real professional world by simulating the context of the future use of knowledge or by placing knowledge within the original context of future use (e.g., Barab & Duffy, 2000; Vos, 2011). Furthermore, most learning activities will involve elements that are widely recognisable as originating from original professional practice (e.g., Vos, 2011). When describing authentic research practices, the focus is thus on the authentic aspects rather than on identifying research practices as authentic as a whole. Findings from previous studies have resulted

in the construction of frameworks characterising the components of authentic learning activities (Newmann & Wehlage 1993; Renzulli, Gentry, & Reis, 2004; Rule, 2006). Findings from Rule's (2006) review study have recently been used in higher education to bridge a gap between student learning activities within the classroom and in professional settings by revealing four factors that promote authenticity in learning activities (Diamond, Middleton, & Mather, 2011). First, authentic learning experiences are promoted by student engagement in real-world professional problems that target a real professional audience. Second, the learning activities should provide opportunities for students to practise their thinking skills. Third, authentic learning experiences enable discourse amongst a community of learners. Fourth, enhancing authenticity should encourage students to direct their learning in accordance with their own interests (Rule, 2006). In the present study we use this framework to focus our description of research practices on authentic aspects of the learning activities.

2.1.2 Student perceptions and beliefs

Student perceptions of the learning environment influence learning experiences as well as their learning outcomes and they can also mediate student behaviour (Biggs, 1985; Ellis, 2016; Pajares, 1992; Ramsden, 1991). Previous studies investigating the role of research within teaching in general have emphasised student perceptions of research in teaching in order to promote various learning outcomes, including research dispositions, research skills and awareness (Visser-Wijnveen, et al. 2012; also see Chapter 4). Yet, it can be difficult for students to perceive research as being integrated into teaching. Further, teachers may consider undergraduates in particular to be intellectually immature or not yet 'open' to research (Brew & Mantai, 2017; Zamorski, 2002). However, findings from previous studies suggest that undergraduates do perceive the benefits and disadvantages of the integration of research into teaching (Healey, Jordan, Pell, & Short, 2010; Lindsay, et al., 2002; Neuman, 1994). Examples of benefits are perceptions of the staff's enthusiasm for research within departments, participation in research and reflections on research products (Neumann, 1994; Robertson & Blackler, 2006; Turner, Wuetherick, & Healey, 2008; Visser-

Wijnveen, et al., 2016). Nevertheless, a strong focus on the research interests of staff may lead to narrow representations of the field at the expense of students' own interests (Healey, et al., 2010; Lindsay, et al., 2002; Neumann, 1994). Student perceptions of research in teaching can be influenced by their beliefs regarding, for example, the purpose of university teaching (e.g., Pajares, 1992; Robertson & Blackler, 2006). In this study, therefore, data is gathered on student perceptions of research integrated into teaching as well as student beliefs regarding the relevance of research to learning and professional practice.

The literature is ambiguous in terms of the influence of year of study on student perceptions and beliefs about research. Previous studies have provided point-in-time snapshots of student perceptions of research in the learning environment in a variety of disciplines and they suggest that there is no relation between the year of study and perceptions of research (van der Rijst, Visser-Wijnveen, Verstelle, & van Driel, 2009). These findings indicate that student perceptions of research remain stable regardless of the research practices employed in the learning environment, while student beliefs regarding the relevance of research integrated into student learning can become stronger over the years of study (Lindsay, et al., 2002; Neumann, 1994). However, Verburgh and Elen (2011) found that first-year students report more positive beliefs regarding research. Furthermore, previous studies into authentic research practices within study programmes have mainly focused on teaching in one-to-one settings, such as supervision in students' research projects or teaching in small group settings (e.g., Wald & Harland, 2017; Gardner, Forrester, Jeffrey, Ferzli, & Shea, 2015; Sadler, Burgin, McKinney, & Ponjuan, 2010). This large-scale study aims to contribute to the knowledge base by providing a longitudinal view of student perceptions and beliefs regarding research in relation to authentic research practices in undergraduate medical education.

2.1.3 Research aim

The aim of this study is to describe the influence of authentic research practices on student perceptions of research and student beliefs regarding the relevance of research to learning and practice. This large-scale longitudinal study was conducted in the context of a curriculum change within the medical domain, which serves as an example of a hard-applied discipline (Biglan, 1973). Furthermore, this study provides a longitudinal perspective on student perceptions and beliefs regarding research by focusing on a three-year undergraduate medical education programme. First, we describe characteristics of authentic research practices within the study programme. Second, we focus on relations between authentic research practices, student perceptions of research in teaching and student beliefs regarding the relevance of research for practice and learning. Results from this study will be of importance to teachers and academic developers who aim to strengthen the connections between research, teaching and student learning within higher education.

2.2 Educational context: the undergraduate medical programme and student research practices

Undergraduate curricula provide a space for strengthening the role of research within teaching, especially when the curricula reflect research processes and practices in the discipline (e.g., Fung, 2017; Healey & Jenkins, 2009). Findings from studies into research integrated into curricula indicate that fruitful integration relies on the use of a well-considered variety of approaches. These approaches may be based on students' roles in learning activities incorporating research, the chosen focus or topics for fostering student understanding of research, recent research conducted within institutes and the desired student learning outcomes (e.g., Healey & Jenkins, 2009; Verburgh, Schouteden, & Elen, 2013; Zimbardi & Myatt, 2014). This large-scale study was conducted in the context of a curriculum change that aimed to strengthen the integration of research into teaching through authentic research practices. The curriculum change involves all three years of undergraduate medical education at the Leiden University Medical Center (LUMC), which is part of the oldest research-intensive university in the Netherlands.

Academics employed at LUMC are responsible for patient care, research and teaching. The medical undergraduate programme is structured into a bachelor and master's phase. During the three-year bachelor phase students attend patient interviews in addition to attending predominantly theoretical classes augmented by learning activities in small groups. The master's phase consists of clinical placements and a final-year student research project with a minimum duration of twelve weeks. In both phases students are taught by academic staff who are involved in medical scientific research, clinical care and teaching undergraduate courses. Every academic year 330 students, with an average age of 19 years, start studying medicine at the LUMC. The students participating in this programme were admitted to medical education through a weighted lottery procedure based on their grade point average in secondary education until 2014. Students with a high GPA are more likely to be admitted to the programme. From the academic year 2012-2013 onwards, a curriculum change was gradually implemented starting from the first year of study.

Below we describe students' research practices within the previous and changed curriculum, based on course materials such as the online study guide (LUMC, 2017), study materials available to students (i.e., module books) and the experiences of the first and fourth authors, since both were involved in the development and implementation of student research practices in the changed curriculum. The fourth author is a teacher and coordinator of the student research practices. Table 2.1 summarises authentic elements of the student research practices per year of study in the previous and changed curriculum using the characteristics of authentic learning activities as identified by Rule (2006). The research projects conducted during the first and third year were developed within the changed curriculum. The second-year project was a component of the previous curriculum but, since it fits with the aim of the curriculum change, namely to strengthen the integration of research into teaching, it was kept.

When following the changed curriculum, first-year students participate in a small research project related to an early clinical experience in nursing homes. This three-week clinical internship takes place in September, just after the start of the academic year. As part of this project, every student collects data on three patients. In January, during a two-week course on scientific research skills, the students practise formulating a research question and they learn to understand the structure of a research paper in a small-group setting. The students attend lectures on epidemiology, basic statistics as well as a practical in simple data analysis. The students then analyse their data to answer their own research question using the aggregated dataset. They write a two-page research report and present their findings to their peers in a small group session. When designing this project, epidemiology teachers collaborated with primary care teachers.

During the second year of study for both curricula, the students participate as researchers in a three-week course that aims to describe the evidence base of drug advertisements in professional journals for general practitioners through the critical appraisal of the underlying scientific papers (Janmaat, et al., 2013). Again, in small-group sessions, the students apply disciplinary guidelines (Guyatt, Cook, Devereaux, Meade, & Strauss, 2002) in order to learn how to critically appraise research literature. After the small-group sessions the students individually read and appraise a paper. All the students are offered training in different study designs and the basics of statistical data analysis and are given integrated presentation skills training on presenting the results of a research study to peers (cf. simulation; Radinsky, Bouillion, Leton, & Gomez, 2001). This second-year research practice is developed by epidemiology teachers and teachers specialising in academic writing.

Third-year students' research practice is directly related to clinical practice. The students conduct a literature review with the aim of improving the treatment or diagnosis of a specific patient problem under the supervision of a resident. To do this, they use a disciplinary template that is known as a 'critical appraisal of a topic' (CAT; de Brouwer, Mommers, van Gool, Ferreira, & Kant, 2009). The patient problem is formulated by a specialist in training who also individually supervises the students; in this way every student works on an authentic problem. The duration of this project is five months and the students are also simultaneously enrolled in other teaching units simultaneously during those months. At the end of the project, the students present their piece of advice within their clinical department. They also hand in a written CAT report for grading.

Table 2.1. Description of authentic research practices within medical education per year of study (cf. Rule, 2006).

	Student engagement with real-world professional practice	Opportunity for practicing thinking skills	Discourse among learners	Element of students' choice directing learning
First year: Nursing homes (Changed curriculum)	Students participate in internship; research element is an 'add-on'	Formulating research question; practical research skills	Students collaborate in pairs; two small-group sessions	Variables in research question within limited set of variables
Second year: Drug advertisements (Previous and changed curriculum)	In 'ideal' professional practice; simulation	Practicing critical appraisal of research literature	Individual assignment; one small-group session	Research papers are assigned to students
Third year: Critical appraisal of a topic (Changed curriculum)	Students indirectly contribute to real-world patient care	Critical appraisal of research literature; scientific reasoning in a clinical context	Individual assignment; discourse between supervisor and student	Topics are assigned to students; students choose own focus within the topic

2.3 Method

2.3.1 Study design

In this study, a comparison is made between two curricula, (i.e., the previous curriculum and the changed curriculum) over a long period of time, that is, the three years of undergraduate education. Three cohorts of medical undergraduate students participated in this study, in which the authentic research practices are described using Rule's (2006) framework for authentic learning activities. Student perceptions of research and beliefs regarding the relevance of research were obtained using questionnaires. A previous curriculum and a changed curriculum, which incorporates more authentic research practices were compared so as to gain insight into effects of the curriculum on student perceptions of research and student beliefs regarding research.

2.3.2 Participants

Three successive cohorts of students were invited to participate in this study, one following the previous curriculum and two following the changed curriculum. The students were enrolled in the medical programme as first-year students in the academic years 2011-2012, 2012-2013 or 2013-2014, respectively. We distributed hardcopy questionnaires to all first, second, and third year students during lectures at the end of the academic year, that is, between April and June from 2012 until 2016. The questionnaires are explained further below. The students had completed their research practices in the months before. The students were asked to complete the questionnaire for all the subjects they had been enrolled for up till that point. They were asked for permission to use their unique student identification number, which meant we could send questionnaires to those 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 for the study was granted by the LUMC Research Ethics Committee. Not all students completed consecutive questionnaires. Ultimately, 941 students completed the questionnaires at least once during the course of the bachelor programme, while some 228 students completed the questionnaires once per year during their three years of study. In total 322 students following the previous curriculum participated in this study as well as 619 students following the changed curriculum. 72.3% of the students were women, indicating that the sample is representative of the medical student population (van der Velden, Hingstman, Heiligers, & Hanssen, 2008). The students were between 16 and 35 years old in the first-year of their study ($n = 796$; $M = 19.6$; $SD = 1.72$). Some of the students had previous experiences of research ($n = 213$), for example, extracurricular research as part of prior studies before studying medicine or in pre-university colleges.

Table 2.2. Scales, reliability and sample items of the Student Perception of Research Integration Questionnaire for undergraduates following the previous and changed curricula.

Scales	N items	Sample items during this academic year…	α*
Student perceptions			
Critical reflection on research	4	… attention was paid to research methods.	.83
Participation in research	5	… as a student I felt involved in research.	.88
Familiarity with current research	5	… I became familiar with the research carried out by my teachers.	.83
Motivation for research	4	… I became enthusiastic about research in medicine.	.89
Other			
Beliefs regarding the value of research for practice	6	Scientific skills are important for being a doctor.	.92
Beliefs regarding the value of research for learning	3	… the research culture within the institute stimulates my learning.	.87
Quality of learning environment	3	… the teachers carried out their instruction adequately.	.77

*Cronbach's alpha indicates an acceptable to strong internal consistency of scales (Cohen, 1998).

2.3.3 Instrument and procedure

In order to study undergraduate student perceptions of research within teaching we administered an adapted version of the Student Perception of Research Integration Questionnaire (SPRIQ) (Visser-Wijnveen, et al., 2016; also see Appendices 1 and 2). Adaptations were made to particularly fit the medical context and we added a scale about beliefs regarding the relevance of research for clinical practice. For example, we replaced general item wordings such as 'scientific domain' with 'medicine' (see Chapter 4). The version of SPRIQ adapted for medical education is included in Appendix 1. The scales included student perceptions of teaching via (1) critical reflection on the way research results are produced; (2) research participation as a student; (3) familiarity with current staff research; (4) fostering interest and motivation for research and; (5) student beliefs regarding the relevance of research for learning and (6) perceived quality of the learning environment (see Table 2.2 for sample items). We also added a scale concerning beliefs regarding the relevance of research to clinical practice. All 30 items were answered on an agreement scale, that is, a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The quality scale was included because students' opinions on the general quality of teaching during the academic year could influence their scores on the other scales. Table 2.2 shows the scales, reliability for this sample and sample items of the version of SPRIQ that we used.

The aim of this study, to describe the influence of authentic research practices on students' perceptions of research and their beliefs regarding the relevance of research, guided our attention towards particular scales of SPRIQ. The description of authentic elements of research practices (Table 2.1) puts the emphasis on student engagement with real-world professional practice which should enrich their learning experiences with situational, contextual and cultural information about the use of research. It was expected that authentic research practices would foster student motivation for research. Furthermore, immersing students in research practices in a professional setting may serve to foster their beliefs regarding the relevance of research to practice. All students participated in research activities (i.e., data collection, critical appraisal of literature). The

research practices employed during year two and three were designed to promote critical appraisal of research literature and to foster students' thoughts on the use of research in clinical contexts; therefore, it was expected that student perceptions of critical reflection to increase over the years of study. The authentic research practices might have provided opportunities for students to familiarise themselves with staff research, although this was not a primary goal of the curriculum change. For a similar reason, there were no expectations regarding possible changes in the perceived quality of the learning environment. For example, the quality scale was concerned with teaching quality, while the curriculum change did not focus on professional development initiatives intended to foster individual staff members' approaches to research-teaching integration. Finally, it was not expected that the student beliefs regarding the relevance of research to learning would change, since the authentic research practices were more strongly related to the use of research in a clinical context than to, for example, the culture in which scientific research was conducted within the LUMC. For these reasons, we have reported the students' scores on all scales of the SPRIQ in the results section, although we have highlighted the scores for the students' *participation* in research, *motivation* for research, *critical reflection* on the way results are produced and *beliefs regarding the relevance of research to practice.*

2.3.4 Analysis

To assess the influence of authentic research practices on student perceptions of research over the course of an undergraduate programme, a mixed model approach to a repeated measures analysis of variance (ANOVA) was used. This method of analysis allowed us to include students who had completed the questionnaire once or twice during their undergraduate education. The three time points, one per year of study, were used as the repeated factor and student identification numbers were used as subjects. In order to compare the two curricula, the separate student perception and beliefs scales per curriculum were used as the dependent variables. Due to the large number of students included in this study, an unstructured covariance type was used to estimate six parameters by which the observed and the expected scores for all students were compared.

A confidence interval of 95% was applied for all effects. The results we show are the confidence intervals, indicating the size of the effects (e.g., Seltman, 2015).

In order to compare the student perceptions of research practices in the changed curriculum with the previous curriculum, additional t-tests for independent means were conducted. Again, a confidence interval of 95% was applied for all effects.

2.4 Results

First, the student scores for the SPRIQ scales are shown, namely promoting students' sense of *participation* as researchers in learning activities; fostering student *motivation* for research; and student *beliefs regarding relevance to practice*. Figure 2.1 presents the main results, that is, the student scores on *participation, motivation, critical reflection* and *beliefs regarding the relevance of research to practice* over the years of study, with the scores being plotted for both the previous and changed curricula. Second, the descriptive statistics are presented for all the SPRIQ scales in both curricula in Table 2.3.

With regard to *participation, the* students felt more involved in research during the course of the undergraduate programme, although the scores were less than 3 on a five-point Likert scale (see Table 2.3). The scores regarding *participation* were higher for those studying the changed curriculum $[F(2,292.96) = 58.95$, 95% $CI_{yr3-yr1}$ $[-.70, -.47]$, 95% $CI_{yr3-yr2}$ $[-.71, -.48]]$ than for the previous curriculum $[F(2,187.38) = 19.42$, 95% $CI_{yr3-yr1}$ $[-.50, -.24]$, 95% $CI_{yr3-yr2}$ $[-.18, .08]]$. The results for the participation scale indicate that students following the changed curriculum participated more strongly than they had done previously, specifically during the first and third years. This may be explained by the practical, clinical contexts in which the research practices associated with the nursing homes and CAT, respectively, were carried out.

The students' *motivation* for research increased as they progressed through the undergraduate programme when following the changed curriculum $[F(2,305.84) = 19.97$, 95% $CI_{yr3-yr1}$ $[-.35, -.17]$, 95% $CI_{yr3-yr2}$ $[-.40, -.19]]$, but not when following

the previous curriculum $[F(2,190.76) = 2.03$, 95% CI$_{yr3-yr1}$ [-.26, .00], 95% CI$_{yr3-yr2}$ [-.21, .05]]. When comparing the scale means between the curricula, students following the changed curriculum reported a stronger *motivation* for research in medicine, particularly during the first and third years (Table 2.3).

The mean scores for the perceived *critical reflection* presented in Table 2.3 show that students following the changed curriculum experienced a stronger focus on research processes than those following the previous curriculum from the first year onwards ($M_{difference\ yr\ 1} = 0.33$). Prior to the curriculum change, the student perceptions of *critical reflection* in year one were similar to those in the third year, although they decreased a bit in the second year $[F(2,182.45) = 2.90$, 95% CI$_{yr3-yr1}$ [-.11, .14], 95% CI$_{yr3-yr2}$ [-.23, .00]]. After the curriculum change, the perceived *critical reflection* increased slightly over the years $[F(2,327.28) = 34.88$, 95% CI$_{yr3-yr1}$ [-.42, -.25], 95% CI$_{yr3-yr}$ [-.22, -.03]].

The student *beliefs regarding the relevance of research to practice* decreased slightly from year one to year two following the curriculum change and then increased, while the student beliefs about the relevance of research to practice did not change towards their third year $[F(2,291.02) = 4.81$, CI$_{yr3-yr1}$ [.05, .23], 95% CI$_{yr3-yr2}$ [-.01, .18]]. The data concerning the previous curriculum showed a somewhat similar result $[F(2,159.33) = 0.51$, 95% CI$_{yr3-yr1}$ [-.06, .12], 95% CI$_{yr3-yr2}$ [-.10, .08]].

Table 2.3 presents the descriptive statistics for all of the SPRIQ scales used in this study. When following the previous curriculum, the student *beliefs regarding the relevance of research to learning* decreased slightly over time $[F(2,117.11) = 0.69$, 95% CI$_{yr3-yr1}$ [-.07, .19], 95% CI$_{yr3-yr2}$ [-.05, .19]], while the students following the changed curriculum believed that research was more important for learning towards the end of the undergraduate programme $[F(2,303.73) = 26.27$, 95%
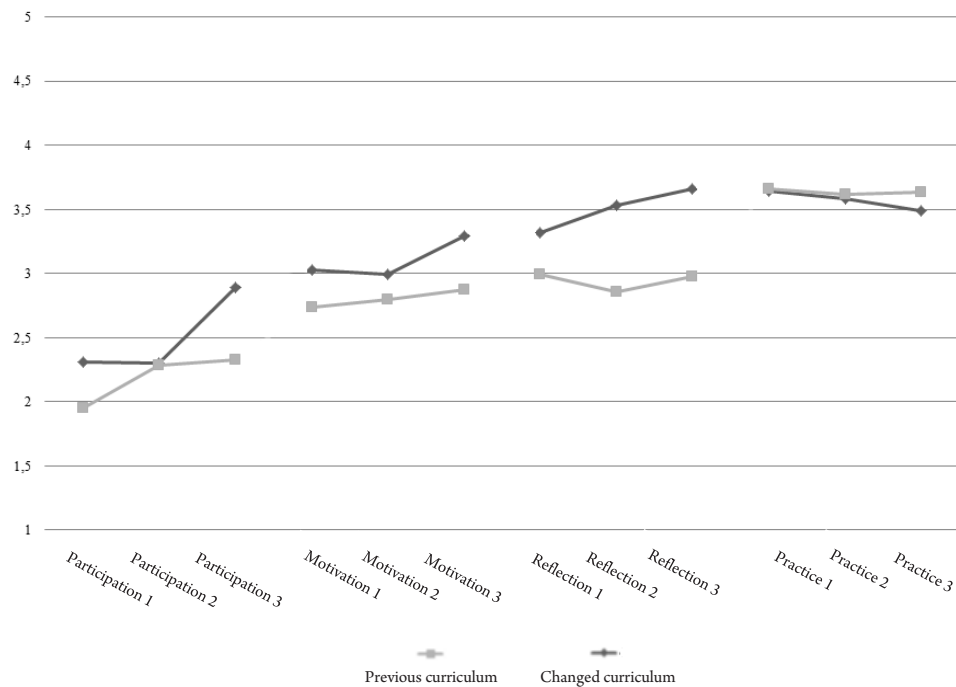

Figure 2.1. Student scores on the scales participation, motivation and beliefs regarding relevance for practice of the Student Perception of Research Integration Questionnaire.

Table 2.3. Descriptive statistics per scale of the Student Perceptions of Research Integration Questionnaire for undergraduates following the previous and changed curricula

	Previous curriculum ($n = 322$)			**Changed curriculum** ($n = 619$)		
Scale	M_{year1} (sd)	M_{year2} (sd)	M_{year3} (sd)	M_{year1} (sd)	M_{year2} (sd)	M_{year3} (sd)
Participation	1.95[c,d] (.69)	2.28 (.81)	2.33[c,e] (.84)	2.31[a,d] (.73)	2.30[b] (.75)	2.89[a,b,e] (.83)
Critical reflection	2.99[d] (.67)	2.86[e] (.70)	2.98[f] (.65)	3.32[a,d] (.62)	3.53[b,e] (.58)	3.66[a,b,f] (.61)
Motivation	2.74[c] (.78)	2.80[d] (.82)	2.87[e] (.81)	3.03[a,c] (.79)	2.99[b,d] (.87)	3.29[a,b,e] (.69)
Familiarity	2.66[b,d] (.68)	2.89[c,e] (.65)	3.11[b,c,f] (.63)	3.06[a,d] (.63)	3.21[e] (.61)	3.24[a,f] (.66)
Quality	3.80 (.51)	3.85[b] (.59)	3.84[c] (.59)	3.75 (.56)	3.52[a,b] (.59)	3.75[a,c] (.59)
Beliefs relevance to learning	3.04 (.80)	3.05[c] (.82)	2.98[d] (.88)	3.06[a] (.81)	2.89[b,c] (.85)	3.31[a,b,d] (.88)
Beliefs relevance to practice	3.66 (.67)	3.62 (.73)	3.63[b] (.72)	3.64[a] (.73)	3.58 (.76)	3.49[a,b] (.79)

Means within the same row that share superscripts differ at p < .05

$CI_{yr3-yr1}$ [-.36, -.15], 95% $CI_{yr3-yr2}$ [-.53, -.30]]. Students consider research to have the least relevance on research to their learning during the second year.

The students who conducted the research activities as part of the changed curriculum felt more *familiar* with their teachers' research from their first to their third year [$F(2,308.04) = 10.85$, 95% $CI_{yr3-yr1}$ [-.27, -.08], 95% $CI_{yr3-yr2}$ [-.11, .07]]. When following the previous curriculum the perceived *familiarity with teachers' research* grew gradually [$F(2,201.19) = 28.89$, 95% $CI_{yr3-yr1}$ [-.57, -.33], 95% $CI_{yr3-yr2}$ [-.34, -.11]].

Overall, the perceived *quality of the learning environment* was lower when following the changed curriculum than before; the scores for the *quality of the learning environment* decreased somewhat during the second year when compared to the first and third year [$F(2,341.66) = 19.18$, 95% $CI_{yr3-yr1}$ [-.08, .08], 95% $CI_{yr3-yr2}$ [-.32, -.14]]. When following the previous curriculum the perceived *quality of the learning environment* was similar from year to year [$F(2,195.53) = 0.76$, 95% $CI_{yr3-yr1}$ [-.13, .06], 95% $CI_{yr3-yr2}$ [-.09, -.11]].

2.5 Conclusions and discussion

This study aimed to assess the influence of authentic research practices within undergraduate medical education on student perceptions of research and student beliefs regarding the relevance of research to both learning and practice. In order to achieve this goal, a comparison was made between a curriculum that aimed to strengthen research integration through authentic research practices and a previous curriculum. Authentic elements within the research practices in this study were described based on a framework for authentic learning (Rule, 2006). This enabled us to create a 'post-hoc' image of research practices within the undergraduate curriculum (cf. Healey & Jenkins, 2009; Zimbardi & Myatt, 2014). The data indicates that students' participation in research, their motivation for research, their perceptions of critical reflection on research findings and their familiarity with staff research all increased following the curriculum change. The results suggest that student beliefs regarding the relevance of research to practice

remain stable over the course of their undergraduate education, regardless of the curriculum change. Furthermore, the findings indicate that students believe research to have greater relevance for learning in authentic research practices towards the end of their undergraduate education.

The analyses of the data revealed that students' sense of active involvement in research and their motivation for research increased modestly towards the end of their undergraduate medical education. Differences found between the curricula with regard to student participation in research and student motivation for research can be explained by the roles that the students played in the authentic research practices. All the research practices actively engaged students in either using or doing research in a clinical, professional setting. This is in line with findings from previous studies into research integrated into teaching which indicate that the students' role, on a dimension from observing to participating in research, is a defining characteristic of learning activities incorporating research (e.g., Healey & Jenkins, 2009). The students who participated in this study were involved in learning activities in medicine. The findings of this study indicate that, in the case of the hard-applied disciplines, the integration of research into student learning activities can benefit from connections with professional practice in diverse settings. Furthermore, the results indicate that a curriculum that includes authentic research practices can promote student motivation for research from the first undergraduate year onwards.

Previous studies concerning students' learning experiences in relation to research in university teaching suggest that students experience both tangible and intangible aspects of research (Neumann, 1992; 1994). Tangible aspects of research-teaching integration involve, for example, the promotion of research skills, while the intangible aspects involve fostering enthusiasm and curiosity (e.g., Neumann, 1994). The findings of this study indicate that, by participating in authentic research practices, the students perceived both tangible (i.e., participation) and intangible (i.e., motivation, critical reflection) connections between research and teaching. The research practices associated with the drug advertisements during the second year and the CAT during the third year were especially designed to foster critical reflections on the research literature. The

data also suggests that the teachers found ways to familiarise students with their own research. Furthermore, the findings indicate that students may perceive a decrease in the quality of teaching within a curriculum designed to integrate real-world research activities into teaching, which in this case, happened during the second year. This implies that the relatively new curriculum could have affected coherence within the study programme due to the unclear expectations of both teachers and students at the time of implementation (e.g., van den Akker, 2003). At the same time, the items from the teaching quality scale were quite generic for the purpose of this study, since they were intended to assess the influence of authentic research practices on student perceptions of research within the study programme.

The student beliefs regarding the relevance of research to professional practice remained stable during the course of their undergraduate education. The findings suggest that the importance placed by students on research in relation to practice is less malleable than their perceptions of research in relation to teaching, which depend more strongly on the curriculum. Our data show that student beliefs regarding the value of research for learning became stronger after the third-year CAT, which indicates that their beliefs regarding the value of research for learning might change over a longer period of time. Previous studies into student beliefs have suggested that beliefs are relatively stable in nature and reflection on one's own beliefs can be fostered through, for example, a reflection on previous learning experiences (Mezirow & Associates, 2000; Pajares, 1992). Based on our findings we suggest that the effectiveness of authentic research practices, in terms of fostering student beliefs about the importance of research for learning, can be enhanced by continuous attention being paid to integrating research into the study programme. This can be achieved, for instance, by adopting a programmatic approach to the implementation of authentic research practices. In line with this, it might be beneficial for future research and teaching to focus on learning activities which allow students to relate their learning experiences to their beliefs regarding research in practice in order for students to connect rather individual pieces of knowledge about the use of research in medical professions.

Questionnaires were used in this study in order to obtain information about student perceptions of research and beliefs regarding the value of research within a large-scale, three-year undergraduate programme. Student perceptions of the learning environment represent a valuable source of information for those involved in strengthening the integration of research into study programmes. Student beliefs function as a lens through which they perceive the learning environment (e.g., Pajares, 1992) and student perceptions of the learning environment can foster learning outcomes (Biggs, 1985; Lizzio, Wilson & Simons, 2002; Prosser & Trigwell, 2014). We suggest that future studies into student perceptions and beliefs regarding research could benefit from further exploration of relations between beliefs, perceptions and student learning outcomes. The use of a questionnaire as part of a longitudinal study design was considered most appropriate due to the scale of the study programme and the curriculum change. Not all the students completed the consecutive questionnaires, which is typical for longitudinal studies. In order to encourage students to participate, all students within the study programme were invited to participate both in class and via email. Furthermore, the method of data analysis was deliberately chosen in order to include all the completed questionnaires.

The description of authentic elements within the research activities highlights student engagement in real-world professional practice. In this case, the first- and third-year research practices stand out, since both were conducted in a clinical professional context. The research practice in the second year was different, since its central goal was to critically appraise research literature in a classroom setting as opposed to conducting research activities in a clinical setting. The description of authentic elements in all three research practices suggests that further exploration of the discourse among learners, either in small-group settings or informally in professional practice could promote authenticity in research activities. Furthermore, student learning could benefit from students being provided with opportunities to follow their own interests, for example, by involving them in the selection of research papers and patient problems within the described research practices.

The results of this study support previous research findings in suggesting that integrating research, in ways that resemble research activities in professional contexts in one of the hard-applied disciplines is effective from the first undergraduate year onwards (cf. Brew, 2010; Spronken-Smith, Mirosa, & Darrou, 2014; Zamorski, 2002). The findings of the present study further suggest that strengthening the role of research in teaching through authentic research practices fosters student participation in research, stimulates students' enthusiasm for research and focuses attention on the ways in which research findings are produced. The findings also indicate that authentic research practices can offer ways for teachers to familiarise students with staff research. In addition, our results suggest that students find research practices that incorporate the use of research in professional practice to stimulate their learning particularly towards the end of the undergraduate programme.