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Table of contents

1

General introduction

Introduction

Research – small word, great impact. According to Cohen, Manion and Morrison (1963, p. 4) research "must be regarded as the most successful approach to the discovery of truth".[1] Truth could be a debated word, as some scientists would say that truth is non-existent. However, one thing we can all agree on is the importance of research for developing knowledge. Within the medical field, research is imperative to make advancements. Physicians combining clinical work and conducting research (i.e. physician-scientists) are essential, but scarce at the same time. Over the last decades, medical education has been suggested to be part of the solution to rescue academic medicine. This thesis focuses on first steps within medical education to stimulate undergraduate medical students to pursue a physician-scientist career, by helping to unravel the role of motivation for research and extracurricular research programmes. With this thesis, I hope to provide insight into the important role early phases of medical education could play in developing the next generation of research oriented physicians – future physician-scientists: let's catch them young!

Problem description

The royal college of physicians and surgeons of Canada developed a framework to enhance physician training in 1990: the Canadian Medical Education Directives for Specialists (CanMEDS).[2] According to the CanMEDS, the physician has seven professional roles, one of which is the role of 'scholar'. Being a scholar is defined by four key competencies:

1. Continuous enhancement of professional activities through ongoing learning (i.e. lifelong learning);
2. Teaching of students, residents, and other healthcare professionals (i.e. teacher);
3. Integration of best available evidence in daily practice (i.e. evidence-informed decision making);
4. Contributing to creation, dissemination, application, and translation of knowledge within healthcare (i.e. conducting research).

A strong research focus can be found within the third and fourth key competency a scholar should master. All physicians should be able to practice evidence-informed decision making and conduct research. However, 'being able to' does not per definition equal 'doing'. In line with many others, I argue that *all* physicians should be able to *use research* in daily clinical work, thereby practicing evidence-informed decision making. Physicians should understand research, be able to critically appraise research, and consequently apply it within their daily practice. Therefore, they should be aware of the newest developments in their field of medicine and recognize uncertainty in practice. By identifying evidence relevant to their particular clinical questions and problems, they provide patients with grounded diagnosis. Moreover, by using research, physicians also contribute to the process of lifelong learning.[2-4]

When it comes to actually conducting research, the distinction between being able to and actually doing something becomes more apparent. According to the CanMEDS, every physician should be able to contribute to the creation, dissemination, application, and translation of knowledge within healthcare, but not every physician has the opportunity or motivation to actually conduct research in real life. However, *some* physicians *conducting research* are imperative to make advancements within the medical field.[4] So called physician-scientists have clinical degrees, provide daily clinical care, but also devote a substantial amount of their time to conducting research (in current literature also referred to as clinician-scientists or clinical researchers).[5]

By being involved in both clinical and research activities, physician-scientists have the unique ability to bridge the gap between medical research and clinical practice. Over the last decades, concerns have been raised regarding this gap: the two fields have become too disengaged and labelled as 'islands', which has serious consequences for the future of academic medicine.[6] The gap between (bio)medical research and clinical application has even been named 'the Valley of Death' – a result from the growing perception that resources are invested in medical research, without resulting in clinical application (e.g. new treatments, diagnostics and prevention for patients).[7,8] This is underpinned by the estimation that 85% of all research funding is wasted.[9] This problem is relatively recent and started around 1970, when biomedical research arose as a distinct discipline, resulting in a separation of clinical and basic research. Physician-scientists became a minority group. However, we have come to realise that physician-scientists do have the best starting point to connect practice and research. By being involved in daily clinical practice, physician-scientists encounter real life clinical problems and questions, which can then be easily translated into proper research designs. On the other hand, the physician-scientist has the opportunity to translate research outcomes into clinical practice and patient care, for instance by developing clinical guidelines. This process of 'bench to bedside' has been advocated by many and goes hand in hand with the appearance of the term 'translational research' – i.e. "the process of translating discoveries in the laboratory into clinical interventions for the diagnosis, treatment, prognosis, or prevention of disease with a direct benefit of human health".[8] In 1993, this term appeared in PubMed for the first time, multiplying ever since.[7] This reflects the growing consensus that translational research and physician-scientists are of crucial importance within medicine, as physician-scientists are fluent in two languages: basic sciences and clinical medicine.[8]

A pioneer in labelling physician-scientists as an endangered species in 1979 was James Wyngaarden, who later became the director of the National Institute of Health (NIH, United States). He elaborated on NIH's research grants and the decreasing number of applicants with an MD or MD/PhD degree, while the corresponding number of PhD applicants without an MD degree increased significantly.[10] The decline in physician-scientists remained a topic of debate in the following decades. The American Medical Association spoke of a 36% decline in physician-scientists from 1985 to 2003.[8] The NIH Physician-Scientist Workforce Working Group published a report in 2014, also elaborating on a significant decline in physician-scientists from 2003 to 2012. In addition, they specifically expressed their concerns regarding the ageing of the physician-scientist workforce, as the age profile has increased slowly over the past decades with a decline in physician-scientists aged 31-60 and an increase in physician-scientists aged 60 or above.[11] Although these numbers reflect on the United States, it has been documented that the physician-scientist problem is apparent in Canada and Europe as well.[3] A study conducted by Lopes and colleagues in the United Kingdom (UK), showed that only one third of the physicians completing a PhD pursued a clinical academic career after obtaining their PhD. Furthermore, they elaborated on findings from the Medical Schools Council stating that over half of the medical schools in the UK report difficulties to fill clinical academic posts.[12] Within the Netherlands, the Rathenau Institute published a report in 2018 showing that the amount of PhDs within medicine increased enormously: 256% in 25 years.[13] However, this is not reflected in the amount of MD/PhDs subsequently pursuing a research oriented career. Of all PhDs in the Netherlands, the medical PhD graduates are the least involved in research.[13] Furthermore, a recent Dutch national cohort study reported that less than half of the rapidly growing number of PhD candidates at medical faculties within the Netherlands was actually registered as a physician.[14] In addition, only few MD/PhDs take on a leading role in medical science after completing their dissertation. According to this study and other national studies, medical graduates perceive obtaining a PhD as a requirement to secure a competitive residency spot.[14-16] Hereby, many physicians view obtaining a PhD as part of a preliminary education trajectory to become a medical specialist, not to pursue a research oriented career.[13-16]

To summarize, unfortunately, the medical domain is currently still facing a global physician-scientist shortage.[5,17,18] What emerged as a problem 41 years ago, is still a topic of debate nowadays. Despite the well-known and increasing importance of physician-scientists, a declining interest in academic careers combined with the ageing of the current physician-scientist workforce poses a serious threat. This is also reflected in the emergence of scientific articles with urgent titles, emphasizing that physician-scientists are really becoming an endangered species and the time for action is now.

What kind of action is, then, necessary? This has been an important topic of debate and research. A possible solution to boost the physician-scientist workforce lies in medical education. Decades ago, taskforces established by the Association of American Medical Colleges recommended that clinical research should be introduced in undergraduate medical education curricula.[11] By making both using as well as conducting research clear goals in early phases of medical education, the connection between teaching and research may be strengthened. Furthermore, students get acquainted with research. This helps them to understand, critically appraise, and subsequently use research,[19] providing every student with an academic mindset to practice evidence-informed decision making (the third key competency of the CanMEDS ‘scholar’ role) in future professional practice. Additionally, it might help to identify a research career path for a subset of students. By being exposed to research during medical training, students’ motivation and enthusiasm for conducting research could be triggered (the fourth key competency of the CanMEDS ‘scholar’ role). Lastly, it could also help educators to recognize and develop research talent.[4,20,21] Hereby, medical education could serve as a ‘breeding ground’ for physician-scientists.

The aim is clear: engaging students in research during medical school with the two-fold purpose of delivering graduates with an academic attitude and stimulate a subset of graduates to pursue a physician-scientist career. This can be established in two ways: intra- and extracurricular. When looking at the past decade, both ways to engage students in research are being implemented, though in diverse manners.[3,22-24]

Student involvement in research: core curriculum

By integrating research into medical curricula, every student can be engaged in research. Multiple frameworks to enhance student engagement in research have emerged.[25-27] Healey and colleagues have developed a framework to explain four ways in which students can experience research in the curriculum. Healey distinguishes a dimension of students viewed as audience versus active participants, while within the second dimension the emphasis can be on the research process or content. This leads to four quadrants to illustrate student experiences with research within the core curriculum.[25] This framework, however, could be interpreted in different ways. For instance, if a student individually conducts research from start to end, the emphasis is both on research content as well as research processes – making it hard to decide in which quadrant to place this activity. However, of crucial importance within this framework seems to be the distinction between students as audience or active participants. Students benefit from actively being involved in research. Active learning, or 'learning by doing', is seen as the most optimal way to engage students in activities. The idea of learning by doing, in which students are seen as active participants instead of passive consumers of information, was already advocated by John Dewey.[28] Since that time, many theoretical frameworks emerged, emphasizing the importance of active learning; for instance Healey's framework. In order to deliver capable 'scholars', it is imperative to actively involve students in conducting research.

Attempts to involve undergraduate students in formal research during medical education, however, remain inadequate.[22] Concrete translations of existing frameworks to educational practice might be helpful – I hope this thesis not only helps to clarify how such courses for large group of undergraduates contribute to cultivating future physician-scientists, but also provides some tools for how to implement such a course in one's medical curriculum as well.

Motivation for research in undergraduate medical education

The opportunities to engage students in research seem to exist, however, the question remains how to foster future physician-scientists at an early stage. In order to establish this goal, motivation for research seems key.

In general, motivation can be defined as what ‘moves’ people to action. Motivational theories emerged in the 20th century. These theories tend to view motivation as a unitary entity, focusing on the amount of motivation a person has.[29] An example is Bandura’s Social Cognitive Theory (SCT), focusing on the level of motivation, differentiating between motivated versus unmotivated behaviour. SCT states that self-efficacy is the underlying mechanism for motivation and that a lack of self-efficacy results in unmotivated behaviour. Self-efficacy can be defined as a person’s belief in his or her own ability to achieve certain outcomes.[30]

Ryan and Deci’s Self-Determination Theory (SDT)[29] is different from other motivational theories, as it focuses on the *quality* (as opposed to solely quantity) of motivation. SDT is an empirically based theory of human behaviour, focusing on social conditions that support or hinder human flourishing. SDT distinguishes two types of motivation. The first is ‘intrinsic motivation’, which is defined as showing behaviour or being involved in a certain activity out of pure interest or enjoyment. In contrast, ‘extrinsic motivation’ represents behaviour or involvement in a certain activity because it is externally rewarding like avoiding punishment, gaining social approval, or achieving a valued outcome. Extrinsic motivation can be divided into four categories, depending on the level of self-determination: external regulation (i.e. behaviour is directly controlled by external forces like rewards or punishment), introjected regulation (i.e. external controls are taken in, but not fully accepted, there is a focus on approval from self and others), identified regulation (i.e. identification with and conscious valuing of an activity), and integrated regulation (i.e. identifications are integrated with a person’s other values and beliefs). So, SDT distinguishes intrinsic from extrinsic motivation, while stating that intrinsic motivation is of better quality. Intrinsic motivation is believed to be related to general wellbeing, deep learning approaches, and better academic performance.

According to SDT, three basic psychological needs must be met in order to enhance intrinsic motivation. First, the need for autonomy – i.e. the need to self-regulate your actions or control the course of your life. Second, the need for competence – i.e. the need to feel effective in dealing with your important life contexts (note: the need for competence touches upon Bandura’s concept of self-efficacy). Third, the need for relatedness – i.e. the need to feel socially connected to others.[29]

In recent years, SDT and many studies using SDT have made another distinction: autonomous versus controlled motivation. Here, intrinsic motivation, integrated regulation and identified regulation (the latter two being the most internalized forms of extrinsic motivation) are defined as autonomous motivation. In contrast, external regulation and introjected regulation are seen as controlled motivation.[29] A visual representation of the different continuums of the SDT is displayed in figure 1.

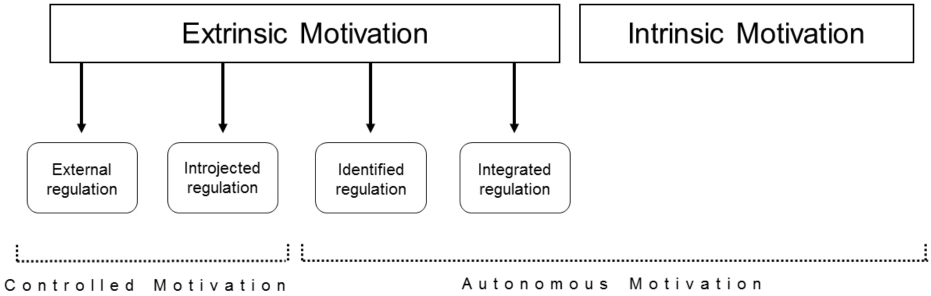

Figure 1. Overview of motivation continuum according to Self-Determination Theory

To some readers, this explanation of the theory might remain quite abstract. When applying this theory to the specific context of this thesis, namely medical student motivation for research, the following interpretations could be given:

1. Intrinsic motivation for research: conducting research out of pure interest or enjoyment;
2. Extrinsic motivation for research: conducting research because it is rewarding, for instance to distinguish yourself and secure a competitive residency spot.

In this context the four categories of extrinsic motivation could be interpreted as:

3. External regulation: conducting research because it is an obligation within the educational programme (e.g. ‘I need to pass this course, so I need to conduct research’);
4. Introjected regulation: conducting research to gain approval from others or avoid shame (e.g. ‘My father thinks research is very important; I am conducting research to make him proud’);
5. Identified regulation: conducting research because it is deemed personally valuable (e.g. ‘I want to know if I am capable of conducting research, which is why I choose to conduct research’);

6. Integrated regulation: conducting research because it is part of your value system as a physician (e.g. 'every good physician needs to be able to conduct research, I want to be a good physician, so I am choosing to conduct research').

The key difference between intrinsic motivation and integrated regulation seems to be the fact that, when intrinsically motivated, a student *likes* conducting research. Within integrated regulation, the student might value research and see the benefits, but this does not automatically mean students conduct research out of pure interest or the innate wish to do so.

In order to stimulate undergraduate medical students to pursue a physician-scientist career and continued engagement in life-long learning, promoting intrinsic motivation seems essential. As the aim is to foster continued engagement in research, working towards a physician-scientist career and identity, it seems key that the medical student actually enjoys conducting research: not only valuing it for professional practice but also invested in staying engaged in a life-long process of research and learning. This vision is in line with research of Ranieri and colleagues among medical professionals, elaborating on the importance of intrinsic motivation for career progression and persistence in academic medicine.[31] Within this thesis, SDT will be used as a theoretical framework and the emphasis will therefore be on the distinction between intrinsic and extrinsic motivation (and not autonomous versus controlled motivation), perceiving intrinsic motivation for research as the target outcome in medical students.

With regard to motivation in general, previous studies have shown that medical students are highly motivated. This is believed to be the result of their large investments to enter medical school.[32] However, less is known about medical students' motivation specifically for research. Vereijken and colleagues studied interest and motivation for research after a curriculum change in which research integration was strengthened. Their findings suggest that students' motivation for research increased when research was more integrated in the curriculum.[33] However, no distinction between type of motivation was made within this study. Some studies investigated motivation for research and suggested that medical students seem motivated to conduct research, but foresee many difficulties and barriers as well.[3,34-36] Studies relying on a sound theoretical framework are scarce. One study performed by Rosenkranz and colleagues did use a theory, namely SDT, and indicated that students view research as valuable for their future medical career. However, these results were mainly gathered among students in clinical phases of medical education.[37] To conclude, there seems to be a lack of studies with a theoretical foundation that focus on pre-clinical phases. Therefore, the first main focus of this thesis is unravelling the role of motivation for research among students in early phases of medical education, while using SDT and subsequently distinguishing intrinsic from extrinsic motivation.

Student involvement in research: extracurricular research programmes

Besides engaging students in research at the curriculum level, students can also be involved in research through extracurricular research programmes. Such programmes are emerging worldwide, though occurring under different names and in diverse formats. They do, however, share the goal to provide a selection of students with research experience and stimulate in-depth inquiry. Examples of such extracurricular research programmes are MD/PhD programmes, capstone programmes, summer research programmes, scholarly concentration programmes and Honours programmes.[3,23,38] For instance, Warren Alpert Medical School of Brown University offers an elective scholarly concentration programme, providing students with the opportunity to undertake a research project of approximately three years.[39] Another example is Vanderbilt University School of Medicine, which implemented an undergraduate medical research programme to provide students with early research experiences.[40] Many more of these programmes are emerging worldwide as a result of national initiatives to put student research on the map. For example, in the US, the National Institute of General Medical Sciences funds Medical Student Training Programmes – nowadays, 43 programmes exist as a result of this initiative.[11] According to Roberts, nearly all US medical schools offer some sort of joint MD/PhD programme.[8]

After performing a systematic review on the outcomes of such programmes, Chang and Ramnanan concluded that attitudes of medical students towards research are predominantly positive. Furthermore, such programmes contribute to enhancing research skills (though self-reported), which may stimulate a continued interest in conducting research. However, this is not reflected in increasing numbers of physician-scientists. According to Chang and Ramnanan's review study, there were multiple discouraging factors like high expectations despite the limited time, inappropriate acknowledgment, and lack of mentorship.[3] Havnaer and colleagues performed a systematic review as well and concluded that scholarly concentration programmes seem promising, however, the authors also emphasized the dearth of evidence with regard to the effectiveness of these programmes in promoting research productivity of medical students.[23]

In sum, some studies attempted to investigate the effectiveness of extracurricular research programmes. However, there is a need for longitudinal research with a control group as a comparison.[3,23,41] Therefore, the second main focus of this thesis is unravelling the role of extracurricular research programmes in contributing to developing future physician-scientists by using a longitudinal design with a comparable control group.

Research context

All studies in this thesis are conducted among undergraduate medical students at Leiden University Medical Center (LUMC) in the Netherlands. In the Netherlands, eight medical faculties (i.e. academic hospitals) offer medical education. All faculties are comparable in the structure of their educational programme, with six years of undergraduate medical education, divided in a three-year programme leading to a Bachelor's degree – which is the main context of the studies within this thesis – and a subsequent three-year programme leading to a Master's degree in Medicine. All eight faculties developed and implemented their educational programme in line with the Dutch National Blueprint for Medical Education, which is based on international educational frameworks like the CanMEDS. In the Netherlands, most students start medical school immediately after graduating from high school, at the age of 18-19 years.[42] Consequently, the population of first-year medical students in the LUMC is of young age and does not have any research-related experience prior to entering medical school.[43]

Research questions and focus of this thesis

To conclude, unravelling the role of motivation for research and extracurricular research programmes is valuable in order to gain insights into ways to develop future physician-scientists starting as early as undergraduate medical training. More insights into how intrinsic motivation for research could be promoted early on in medical school could help to determine possibilities for interventions and the implementation of evidence-based strategies, both intra- and extracurricular, to enhance motivation for as well as involvement in research among medical students. Thereby, first steps can be made to develop the physician-scientist workforce of the future – let's catch them young!

Following these gaps in our knowledge, the overall aim of this thesis is to provide insight into the important role early phases of medical training could play in developing the next generation of physician-scientists by focusing on unravelling the role of motivation for research and extracurricular research programmes. Through these studies we intend to contribute to the quality of undergraduate medical education and delivering graduates who comply to the 'scholar' role as proposed by the CanMEDS framework. To fulfil this aim, we conducted different studies which are described below and will be discussed in detail in the upcoming chapters.

1. Unravelling the role of motivation for research

In *chapter 2* we survey medical students at the start of medical training to identify their intrinsic as well as extrinsic motivation for research, and factors influencing their levels of motivation at the start of medical training. In *chapter 3* we identify conditions under which first-year medical students develop positive perceptions of and motivation for research, using a grounded theory approach. In *chapter 4*, we study the effect of first-year medical students' motivation for research on actual research involvement. In *chapter 5*, we investigate if a success experience within an obligatory research course is associated with an increase in motivation for research and research self-efficacy beliefs. In addition, we research whether the possible effect of a success experience differs when type of assessment is taken into account, looking at standard (i.e. written exam) versus more authentic (i.e. report and oral presentation) assessments. In *chapter 6* we examine if medical students who publish before graduation are more likely to publish after graduation, if they publish a greater number of papers after graduation, and if they publish papers with a higher citation impact after graduation. *Chapter 7* is a commentary, in which we argue around the nature of students' motivation for research as preparation for residency. In particular, we discuss core competencies of the scholar and our vision on the dynamic character of motivation.

2. Unravelling the role of extracurricular research programmes

In *chapter 8* we describe the research-based Honours programme of Leiden University Medical Center, which aims to engage future physicians in scientific research in early stages of medical training. In *chapter 9*, we report on the role of grades in selecting students for an extracurricular research programme. Here, we compare students within the extracurricular research programme with a first-year grade point average (GPA) below or above seven on academic performance, extracurricular research programme performance, and motivational factors. In *chapter 10*, we use a prospective, longitudinal design with a sound baseline measure and a comparable control group to investigate the effects of a research-based Honours programme. Students participating within the extracurricular research programme are compared to students that showed interest in the programme but eventually decided not to participate on academic achievement, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity.

3. Connecting research to theory and practice

As mentioned before, the aim of this thesis was broader than helping to clarify in what way undergraduate courses and extracurricular research programmes contribute to cultivating future physician-scientists. In addition, within this thesis, we wanted to make a connection to both theory and practice. In *chapter 11* we focus on expanding our theoretical view on Self-Determination Theory by including an authenticity framework to shape undergraduate research experiences in such ways that student wellbeing is promoted. Furthermore, elaborating on how an undergraduate research course could be implemented within the medical curriculum seems valuable in order to make a connection to practice. Therefore, in *chapter 12* we provide twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students, based on theory, own experiences, and the previous chapters of this thesis.

A summary and in-depth discussion of the main research findings, directions for future research, and practical implications is discussed in *chapter 13*.

An overview of all chapters including the specific research questions is given in Table 1.

Table 1. Studied research aim/questions, and corresponding research methods and analyses

Chapter	Research aim or question(s)	Research method	Analyses
2	1. To what extent are first-year medical students intrinsically and/or extrinsically motivated for research? 2. What influence do self-efficacy, perceptions of research, curiosity, and need for challenge have on intrinsic and extrinsic motivation for research?	Student surveys (cross-sectional)	Multivariate linear regression analyses
3	1. How do first-year medical students perceive research? 2. Which factors contribute to motivation or demotivation for conducting research?	Interviews	Grounded theory approach: open, axial and selective coding
4	What is the effect of motivation for research on actual research involvement?	Student surveys (prospective cohort)	Multivariate logistic regression analyses
5	1. What is the influence of a success experience within an obligatory research course on motivation for research and research self-efficacy? 2. Is the effect of a success experience different for standard (i.e. written exam) versus more authentic (i.e. report and oral presentation) assessments?	Student surveys (prospective cohort)	Multivariate linear regression analyses
6	Are medical students who publish before graduation more likely to publish after graduation, do they publish a greater number of papers after graduation, and do they publish papers with a higher citation impact after graduation?	Bibliometric methods (retrospective cohort)	Chi square test, Mann-Whitney U test, independent samples t-test
7	Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency	Commentary	n.a.
8	Using an extracurricular Honours programme to engage future physicians into scientific research in early stages of medical training	Monograph	n.a.
9	What is the effect of students' first-year academic performance on academic success within an extracurricular research programme, intrinsic motivation for research, self-efficacy beliefs, perceptions of research and curiosity?	Student surveys (prospective cohort)	Multivariate logistic and multivariate linear regression analyses
10	What is the effect of an extracurricular research programme on academic achievement, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity?	Student surveys (longitudinal)	Multivariate logistic and multivariate linear regression analyses
11	How does engaging in authentic research at undergraduate level contribute to student wellbeing?	Theoretical essay	n.a.
12	Connecting research to practice: Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students	Twelve tips article: practical tips based on theory, previous research, and own experiences	n.a.

References

1. Cohen L, Manion L, Morrison K. *Research methods in education*. Routledge; 2013.
2. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
3. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
4. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
5. Sklar DP. We Must Not Let Clinician-Scientists Become an Endangered Species. *Academic Medicine*. 2017;92(10):1359-1361.
6. DeLuca GC, Ovseiko PV, Buchan AM. Personalized medical education: Reappraising clinician-scientist training. *Science translational medicine*. 2016;8(321):321fs2.
7. Butler D. Translational research: crossing the valley of death. *Nature*. 2008;453(7197):840-842.
8. Roberts SF, Fischhoff MA, Sakowski SA, Feldman EL. Perspective: Transforming science into medicine: how clinician-scientists can build bridges across research's "valley of death". *Academic Medicine*. 2012;87(3):266-270.
9. Macleod MR, Michie S, Roberts I, et al. Biomedical research: increasing value, reducing waste. *Lancet*. 2014;383(9912):101-104.
10. Wyngaarden JB. The clinical investigator as an endangered species. *The New England journal of medicine*. 1979;301(23):1254-1259.
11. NIH. Physician-scientist Workforce (PSW). Working Group Report. NIH Web site. http://acd.od.nih.gov/reports/PSW_Report ACD_06042014.pdf. Updated June 1, 2014. Accessed February 3, 2020. 2. NIH. Biomedical Research Workforce. 2014.
12. Lopes J, Ranieri V, Lambert T, et al. The clinical academic workforce of the future: a cross-sectional study of factors influencing career decision-making among clinical PhD students at two research-intensive UK universities. *BMJ open*. 2017;7(8):e016823.
13. Koier E, de Jonge J. *De zin van promoveren – Loopbanen en arbeidsmarktperspectieven van gepromoveerden*. Den Haag: Rathenau Instituut;2018.
14. Wolters FJ. Academische carrièreperspectieven van gepromoveerde dokters: een landelijk cohortonderzoek in de periode 1992-2018. *Nederlands Tijdschrift voor Geneeskunde*. 2020.
15. Witjes S, Schol R. Niet elke specialist hoeft te promoveren. *Medisch Contact* 2014.
16. Bontje W. Is een doctor een betere dokter? *Arts in Spe*. 2018.
17. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
18. Brass LF, Akabas MH. The national MD-PhD program outcomes study: Relationships between medical specialty, training duration, research effort, and career paths. *Jci Insight*. 2019;4(19).
19. Walkington H, Griffin AL, Keys-Mathews L, et al. Embedding Research-Based Learning Early in the Undergraduate Geography Curriculum. *Journal of Geography in Higher Education*. 2011;35(3):315-330.

20. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching.* Dordrecht: Springer Science + Business Media; 2014.
21. Graham MJ, Frederick J, Byars-Winston A, Hunter AB, Handelsman J. Increasing Persistence of College Students in STEM. *Science.* 2013;341(6153):1455-1456.
22. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online.* 2013;18.
23. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education.* 2017;6(4):216-226.
24. Scager K, Akkerman SF, Pilot A, Wubbels T. Challenging high-ability students. *Studies in Higher Education.* 2014;39(4):659-679.
25. Healey M, Jordan F, Pell B, Short C. The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International.* 2010;47(2):235-246.
26. Willison J, O'Regan K. Commonly known, commonly not known, totally unknown: a framework for students becoming researchers. *Higher Education Research & Development.* 2007;26(4):393-409.
27. Verburgh AL, Schouteden W, Elen J. Patterns in the prevalence of research-related goals in higher education programmes. *Teaching in Higher Education.* 2013;18(3):298-310.
28. Dewey J. *Democracy and education.* Mineola, NY: Dover Publications, Inc.; 2004.
29. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* Guilford Publications; 2017.
30. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.
31. Ranieri V, Barratt H, Fulop N, Rees G. Factors that influence career progression among postdoctoral clinical academics: a scoping review of the literature. *BMJ open.* 2016;6(10):e013523.
32. Ten Cate TJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. *Medical Teacher.* 2011;33(12):961-973.
33. Vereijken MWC, van der Rijst RM, van Driel JH, Dekker FW. Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. *Advances in health sciences education: theory and practice.* 2018;23(2):371-385.
34. Murdoch-Eaton D, Drewery S, Elton S, et al. What do medical students understand by research and research skills? Identifying research opportunities within undergraduate projects. *Medical Teacher.* 2010;32(3):e152-e160.
35. Nel D, Burman RJ, Hoffman R, Randera-Rees S. The attitudes of medical students to research. *South African Medical Journal.* 2014;104(1):32-36.
36. Burgoyne LN, O'Flynn S, Boylan GB. Undergraduate medical research: the student perspective. *Medical Education Online.* 2010;15(1):5212.
37. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education.* 2015;15(1):95.
38. Bierer SB, Chen HC. How to Measure Success: The Impact of Scholarly Concentrations on Students-A Literature Review. *Academic Medicine.* 2010;85(3):438-452.

39. Boninger M, Troen P, Green E, et al. Implementation of a Longitudinal Mentored Scholarly Project: An Approach at Two Medical Schools. *Academic Medicine.* 2010;85(3):429-437.
40. Brown AM, Chipps TM, Gebretsadik T, et al. Training the next generation of physician researchers - Vanderbilt Medical Scholars Program. *BMC Med Educ.* 2018;18.
41. Kool A, Mainhard T, Jaarsma D, van Beukelen P, Brekelmans M. Effects of honours programme participation in higher education: a propensity score matching approach. *Higher Education Research & Development.* 2017;36(6):1222-1236.
42. Wijnen-Meijer M, Burdick W, Alofs L, Burgers C, ten Cate O. Stages and transitions in medical education around the world: clarifying structures and terminology. *Medical Teacher.* 2013;35(4):301-307.
43. Ten Cate O. Medical education in the Netherlands. *Medical Teacher.* 2007;29(8):752-757.

2

Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students

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Abstract

Introduction: The medical field is currently facing a physician-scientist shortage. One possible solution is to direct medical students towards a research oriented career. To do so, knowledge is needed on how to motivate medical students to do research. Therefore, this study examines motivation for research and identifies factors influencing intrinsic and extrinsic motivation for research among first-year medical students.

Methods: First-year medical students were surveyed at the beginning of their bachelor's programme in 2016. On a 7-point Likert scale, students reported their motivation for research, self-efficacy, perceptions of research, curiosity, and need for challenge. Regression analyses were used to examine the influence of these factors on students' motivation for research.

Results: Out of 316 approached students, 315 participated (99.7%). On average, students scored 5.49 on intrinsic, and 5.66 on extrinsic motivation for research. All factors measured influenced intrinsic and extrinsic motivation for research significantly and positively, also after adjusting for gender and age. Cumulative regression showed that these factors explained 39.6% of the variance in intrinsic, and 14% in extrinsic motivation for research.

Discussion: All factors play an important role in intrinsic and, to a lesser extent, extrinsic motivation for research. First-year medical students' motivation for research could be enhanced by stimulating positive self-efficacy beliefs, positive perceptions of research, and curiosity. Also, it is important to fulfil students' needs for challenge by stimulating them to actively conduct research. Thus, to catch students young and cultivate physician-scientists, students should be stimulated to engage in research from the beginning of medical training.

What this paper adds

This paper builds on existing literature that advocates engaging medical students in research to counteract the decline of physician-scientists. Studies focusing on motivating medical students for research are scarce, and mainly concentrate on clinical phases. Moreover, those studies often lack a sound theoretical framework. We used Self-Determination Theory to investigate motivation for research among first-year medical students. Our findings show that first-year medical students are already motivated for research and that their motivation is influenced by self-efficacy, perceptions of research, curiosity, and need for challenge. This offers possibilities to 'catch students young' and stimulate early engagement in research to cultivate physician-scientists.

Introduction

According to the Canadian Medical Education Directives for Specialists (CanMEDS), all physicians should be able to critically appraise and use research in clinical practice to form decisions and make a grounded diagnosis.[1] Furthermore, it is necessary for physicians to keep up with current developments within their field of expertise.[2] To use research and apply evidence–based practice, physicians should be able to understand research.[3-6]

Not only should all physicians use research, there is also a need for physicians to conduct research. Research can contribute to the creation of new knowledge, which is necessary to keep physicians up-to-date and to make progress in the dynamic world of medical healthcare.[4,5,7] Physician-scientists can bridge the gap between science and practice, by translating research outcomes into clinical settings.[8-11] Moreover, physician-scientists encounter actual relevant clinical questions and problems, which can serve as inspiration for scientific research.[12]

Currently, there is a shortage in the number of physician-scientists, as too few physicians pursue a scientific career.[1,8,11,13-15] In a recent review, Chang and Ramnanan stated that in Europe, the United States, and Canada, interest in research among physicians is still decreasing.[1] Milewicz and her colleagues published a report in 2015 showing that too few young physicians pursue a scientific career, stressing the urgent need to direct more physicians towards research.[16] To summarize, the medical field is developing rapidly, and consensus exists on the urgent need for more physician-scientists. However, how future physicians can be stimulated to pursue a scientific career is still debated.[4,8,9,17-21]

Recent literature suggests that early engagement of medical students in research might be an effective solution.[1-5,11,21,22] This may not only help to trigger enthusiasm and stimulate future engagement in research,[1,23,24] but may also help to recognize talent and to help this talent develop into physician-scientists.[25]

To stimulate medical students for and keep them interested in research, it is important to know what motivates them for doing research in early phases of medical training and which factors contribute to their motivation for research. Most medical students in the Netherlands start their medical education after graduating from high school, at the age of 18-20 years. It is unknown if these young students recognize the importance of doing research, and in what way they are motivated to do research.

With regard to motivation in general, studies have shown that medical students are highly motivated, because of their large investment in entering medical school.[26] Less is known about their motivation specifically for research and studies relying on a sound theoretical framework are scarce. One study using Self-Determination Theory (SDT) indicated that students view research as valuable for their future medical career.[3] However, these results were mostly applicable to students in clinical years, and less to students in pre-clinical phases.

SDT distinguishes two main types of motivation: intrinsic and extrinsic motivation. Furthermore, SDT identifies three basic psychological needs influencing motivation: the need for competence, autonomy, and relatedness.[26,27] In this study, we focus on the outcome measures of the SDT, namely intrinsic and extrinsic motivation. In the context of medical education, students can be *extrinsically* motivated to do research because it is beneficial for future training and career opportunities, for example to secure a competitive residency spot.[1,11,28-30] Additionally, there is evidence that students can be *intrinsically* motivated for research, and participate out of interest and enjoyment.[11,28,29] Students could also have both intrinsic and extrinsic motives for doing research.[31]

We investigated four factors that may influence intrinsic and extrinsic motivation to conduct research at the start of medical training. The first factor, *self-efficacy*, is a person's belief in his or her own ability to accomplish a certain outcome.[32] Studies indicated that people are more inclined to follow a certain path if they are confident in their own capability in that domain, and that self-efficacy for research contributes to motivation for a research oriented career.[32-34] In this study, we explored students' beliefs in their general capabilities (i.e. general self-efficacy), academic capabilities (i.e. academic self-efficacy), and research-related capabilities (i.e. research self-efficacy). Previous studies suggested that higher levels of general and academic self-efficacy increase students' engagement in challenging tasks.[35] Doing research is considered to be a complex, and therefore challenging task, especially for first-year students. Therefore all three types of self-efficacy might play a role in influencing motivation for research.

The second factor we investigated was *perceptions of research*: students' beliefs about the value of research and learning. Perceptions of research as a predictor of motivation for research has not yet been investigated. However, a relation between these factors seems plausible. For instance, positive perceptions of research might co-occur with higher motivation for research. If so, it could be valuable to promote positive perceptions of research during medical training.

The third factor we investigated was *curiosity*: the desire to gain new knowledge. Berlyne introduced the concept of 'epistemic curiosity' and described this as 'the drive to know' (1954, p.187).[36] Epistemic curiosity can be divided into two types: interest curiosity concerns the satisfaction in discovering new ideas, and deprivation curiosity concerns the effort spent on finding solutions to a problem.[37] In medical education, students are stimulated to ask questions in order to enhance learning (i.e. interest curiosity).[6] Additionally, students have to solve problems when they encounter difficulties and unknown areas (i.e. deprivation curiosity). Previous research showed that curiosity underlies motivation for and participation in research.[22,24,25] We investigated which type of curiosity was more important in affecting motivation for research. This could provide insights into which type of curiosity should be encouraged explicitly during medical training.

The fourth factor we investigated was *need for challenge*, specifically the need for extracurricular challenges. Some students need extra challenges, which, if not satisfied, could lead to drop out or lower academic performance.[38] If need for challenge influences motivation for research, educators can stimulate students by having them participate in research, for instance by offering challenging research projects.

To investigate if students are motivated to conduct research and which factors influence motivation, we posed the following research questions: 1) to what extent are first-year medical students intrinsically and/or extrinsically motivated for research; and 2) what influence do self-efficacy, perceptions of research, curiosity, and need for challenge have on intrinsic and extrinsic motivation for research among first-year medical students? If we know the nature of students' motivation for research and which factors influence motivation for research, evidence-based strategies can be implemented to enhance medical students' interest in research, and the first step to educate the next generation of physician-scientists can be made. Moreover, it could also have implications for the recruitment of students for medical training, as it could provide insights into how to attract possible future physician-scientists.

Methods

Participants

This study surveyed first-year medical students at Leiden University Medical Center. All students starting their medical education (bachelor's programme) in 2016 were asked to participate in this survey.

Materials

A 7-point Likert type questionnaire consisting of 36 items was composed, ranging from 1 (totally disagree) to 7 (totally agree). We adjusted existing and validated scales in order to focus on research activities and the medical education setting. The scales, reliability, and sample items of the factors as measured by the questionnaire are shown in Table 1. Motivation for research was divided into questions regarding intrinsic and extrinsic motivation. Items for both types of motivation were based on Self-Determination questionnaires. Intrinsic motivation was based on the Interest/Enjoyment Scale,[27,39] and extrinsic motivation on the Value/Usefulness Scale.[27,39] Self-efficacy was divided into questions regarding general, academic, and research self-efficacy. For measuring general self-efficacy, the Dutch General Self-Efficacy Scale was used.[40] For academic self-efficacy, the Academic Efficacy Scale from the Patterns of

Adaptive Learning Scales (PALS) was used.[41] Items on the research self-efficacy scale were self-developed and designed based on the previous two efficacy scales, but more specifically addressing self-efficacy regarding research. Perceptions of research were examined by using the subscale from the Student Perception of Research Integration Questionnaire (SPRIQ) focusing on students' beliefs about the value of research and learning.[42] Curiosity was measured with the Epistemic Curiosity Scale, divided in items on interest and deprivation curiosity.[37] Need for challenge was studied with self-developed items.

Procedure

The questionnaire was translated from English to Dutch, using the forward and backward translation procedure, and pretested on ten second-year medical students. Based on this pilot study, two items were clarified with minor adjustments in the use of words, and all first-year medical students were surveyed. Students were approached by the first author at the beginning of a workgroup session and asked to fill out the questionnaire. They were told that the study was to investigate scientific education in the medical bachelor programme, participation was voluntary, and all data would be processed anonymously. Students who agreed to participate received the questionnaire. This study was approved by the educational institutional review board of Leiden University Medical Center: IRB reference number OEC/OG/20161108/2.

Analysis

We used descriptive statistics to describe demographic variables and previous educational experiences of the students. To estimate the reliability of the scales in the questionnaire, we calculated Cronbach's alpha (Table 1). We calculated mean scores for every scale (range 1 to 7) and used independent t-tests, with Bonferroni correction, to study possible differences between male and female students. To test which factors influence motivation for research, we used linear regressions, adjusted for gender and age. We applied a 95% confidence interval. Based on existing literature we also constructed a cumulative model of explained variance (R^2), starting with the most frequently investigated factors. We analysed all data using IBM SPSS Statistics version 23 for Windows.

Table 1. Scales, reliability, and sample items of the questionnaire used in this study

Scale [a]	*N* items	Cronbach's *α*	Sample item
Intrinsic Motivation	5	.79	Doing research is fun
Extrinsic Motivation	4	.77	I think doing research improves my chances for my preferred residency spot
General self-efficacy	3	.78	I trust my ability to solve problems
Academic self-efficacy	3	.84	If I try I can deal with the most difficult parts of the course
Research self-efficacy	3	.88	I feel I am competent enough to do research
Perceptions of research	5	.83	It is important for medical professionals to have scientific skills
Interest curiosity	5	.80	I enjoy investigating new ideas
Deprivation curiosity	5	.84	If I am busy with a problem, I won't rest until I have the answer
Need for challenge	3	.81	I desire an extra challenge on top of the curriculum

[a] All items were answered on a 7-point Likert scale

Results

Of all 316 students who were approached, 315 students agreed to participate in this study (99.7%). The study included 90 male (28.6%) and 225 female participants (71.4%). Most of the students started medical education immediately after graduating from high school (86.3%), resulting in a sample with a mean age of 18.57 years ($SD = 1.37$). Of these students, 30.2% indicated they had some kind of previous experience with participating in research.

Medical students were intrinsically ($M = 5.49$, $SD = 0.79$) as well as extrinsically ($M = 5.66$, $SD = 0.80$) motivated for research, as can be seen in Table 2 with the descriptives of the sample. Of all students, 30.1% scored a 6 or higher on intrinsic motivation and 42.5% scored a 6 or higher on extrinsic motivation for research. Analysis showed that female students scored slightly higher on both intrinsic and extrinsic motivation for research, but this was not statistically significant ($p = 0.14$ and $p = 0.07$ respectively). The independent t-tests showed that male students scored significantly higher than female students on general self-efficacy ($p < 0.001$, male students scoring 0.39 higher), and academic self-efficacy ($p < 0.001$, male students scoring 0.45 higher). These remained significant after Bonferroni correction (9 tests performed; $\alpha < 0.05 / 9 = 0.0056$). No significant differences between male and female students were found on research self-efficacy ($p = 0.33$), perceptions of research ($p = 0.50$), interest curiosity ($p = 0.61$), deprivation curiosity ($p = 0.35$), and need for challenge ($p = 0.55$).

Table 2. Description of scores on factors measured in the questionnaire [a]

	N	Mean	SD	Min	Max	≥ 6 (%)
Intrinsic Motivation	314	5.49	.79	2.8	7.0	30.1
Extrinsic Motivation	315	5.66	.80	3.0	7.0	42.5
General self-efficacy	315	5.48	.76	2.7	7.0	35.2
Academic self-efficacy	315	5.43	.93	2.3	7.0	36.4
Research self-efficacy	314	4.85	.97	2.0	7.0	18.1
Perceptions of research	315	5.53	.81	2.4	7.0	34.9
Interest curiosity	315	5.46	.77	3.2	7.0	28.1
Deprivation curiosity	315	4.80	1.02	1.6	7.0	16.2
Need for challenge	314	4.10	1.18	1.0	7.0	0.6

[a] Based on a 7-point Likert scale

Univariate linear regression analysis indicated that all factors influenced intrinsic and extrinsic motivation for research significantly, as can be seen in Table 3. The associations remained significant after adjusting for gender and age. All regression coefficients were higher for intrinsic motivation as compared with extrinsic motivation for research.

Table 3. Effects on intrinsic and extrinsic motivation: crude and adjusted for gender and age [a]

	Intrinsic Motivation		**Extrinsic Motivation**	
	Crude β(95% CI)	Adjusted β(95% CI)	Crude β(95% CI)	Adjusted β(95% CI)
General self-efficacy	.257(.154-.360)	.298(.192-.404)	.169(.053-.285)	.213(.095-.331)
Academic self-efficacy	.217(.132-.302)	.320(.168-.340)	.123(.028-.218)	.156(.059-.253)
Research self-efficacy	.370(.297-.444)	.384(.310-.457)	.199(.109-.288)	.209(.120-.298)
Perceptions of research	.430(.339-.520)	.438(.350-.527)	.330(.226-.433)	.338(.235-.441)
Interest curiosity	.447(.354-.540)	.444(.350-.539)	.252(.140-.365)	.250(.138-.362)
Deprivation curiosity	.256(.182-.331)	.245(.169-.320)	.187(.102-.271)	.182(.097-.267)
Need for challenge	.310(.250-.370)	.316(.257-.376)	.189(.117-.262)	.191(.119-.264)

[a] All p-values were below 0.05, all but three p-values were below 0.01

The cumulative linear regression model indicated that self-efficacy explained 25.1% of the variance in intrinsic motivation for research. In this cumulative model, curiosity added 7.8% in explaining the variance, and if need for challenge and perceptions of research were included a total of 39.6% of the variance in intrinsic motivation for research can be explained, as illustrated in Table 4. With regard to extrinsic motivation for research, the total variance explained is 14%, of which self-efficacy contributed 6% and the other factors all together explained 8%.

Table 4. Cumulative model of explained variance of intrinsic and extrinsic motivation for research

Model	Variable	Intrinsic Motivation cum. R^2	Extrinsic Motivation cum. R^2
1	Research self-efficacy	.245	.057
2	Academic self-efficacy	.250	.059
3	General self-efficacy	.251	.060
4	Interest curiosity	.329	.081
5	Deprivation curiosity	.329	.088
6	Need for challenge	.374	.107
7	Perceptions of research	.396	.140

Discussion

This study showed that first-year medical students are already motivated to do research, as they score relatively highly on both intrinsic and extrinsic motivation. Results also show that self-efficacy, perceptions of research, curiosity, and need for challenge are all positively associated with intrinsic and extrinsic motivation for research, also after adjusting for gender and age. The cumulative regression model indicated that around 40% of the variance in intrinsic motivation for research can be explained by the factors included in this study, especially research self-efficacy, interest curiosity, need for challenge, and perceptions of research were important. With regard to extrinsic motivation for research, only 14% of the variance was explained by the factors measured.

On a scale of 1-7 to indicate motivation for research, students scored on average above a 5, which implies that the group was both intrinsically and extrinsically motivated. This is an interesting finding, as one could assume that new medical students would be particularly interested in becoming a clinician. For instance, Rosenkranz and colleagues[3] showed that students in medical training acknowledged the relation between research and keeping up to date, but it was not until they experienced uncertainties in clinical practice that they understood the real relevance of research. A claim that the authors make is that medical students want to be clinicians, and that feelings of the importance of a good doctor conducting research appear in the clinical years of medical training.[3] Our results indicate that our students are already motivated and can see the importance of research at the beginning of their medical training.

Our findings are in line with previous studies in showing that self-efficacy contributes to motivation for research. It has been suggested that physicians with high levels of research self-efficacy are more inclined to pursue a scientific career.[34] Our study suggests that this might also be the case for medical students, with high levels of research self-efficacy enhancing motivation of students for research this early in medical education. This is in line with Bandura's Social Cognitive Theory, which says that self-efficacy has a critical influence on motivation in general.[32] Our study provides support for the applicability of the Social Cognitive Theory in more specific settings, such as motivation for doing research.

Whereas all types of self-efficacy were positively related to both intrinsic and extrinsic motivation for research if tested separately, cumulative testing revealed that general and academic self-efficacy did not contribute to motivation on top of research self-efficacy. It has been argued that first-year medical students see research as a very specific task where very distinct skills are needed.[43] which could mean that the items related to research self-efficacy are more concretely linked to research and thus motivation for research in this sample. Our results indicate that it is valuable to promote positive research self-efficacy beliefs in medical students. Ambiguity and uncertainty regarding an unknown activity may cause lower self-efficacy beliefs.[32] By providing students with more research related experiences early in the curriculum adapted to their level, students can become familiar with doing research. This is also in line with the Social Cognitive Theory, which states that mastery of an activity leads to higher self-efficacy beliefs.[32] With the right support, positive research self-efficacy beliefs can be stimulated, which can contribute to students' motivation for research.

In contrast to earlier studies,[42-44] this study examined perceptions of research as the independent variable. Our results showed that perceptions of research strongly influenced intrinsic and extrinsic motivation. One could argue that students may not be motivated to do research if it does not seem directly valuable for their development (i.e. intrinsic motivation) or future career (i.e. extrinsic motivation). This result could offer great opportunities because perceptions can be influenced.[42,43] By stimulating positive perceptions of research, motivation for research can be enhanced, thus it seems important to structure medical education in a way that positive perceptions are promoted. This could be done by exposing students to conducting research, and emphasizing its relevance for future clinical practice.

With regard to curiosity, the results in this study are in line with earlier findings showing that curiosity influences motivation for research.[22,24,25] It could be that curiosity reflects some kind of eagerness or ambition that underlies motivation, regardless of whether the nature of motivation is intrinsic or extrinsic. Our results indicate that interest curiosity, as well as deprivation curiosity, positively influence motivation for research. Both types of curiosity seemed to matter, but interest curiosity played a greater role in explaining differences in motivation for research. It is desirable to continue to stimulate students' curiosity.

Lastly, our findings showed that some medical students are in need of extra challenges and that this relates to their motivation for research. This indicates the importance of identifying students in need of extra challenges, in order to get them acquainted with the possibility to conduct research, thereby adding research to their options to meet with their need for challenge. In this way, identifying students in need of extra challenges may help to counter the physician-scientist shortage.

Milewicz and her colleagues showed that an MD-PhD programme is a successful approach to train physician-scientists, and argued that this may be extended to postgraduate training as well.[16] Our results, however, suggest that these efforts could be pointed at much younger medical students too, by integrating research much earlier into medical training. Since first-year students are already motivated for research this early in medical training, it is our responsibility as educators to make sure that this motivation does not evaporate.

Limitations and strengths

A first limitation of this study is its cross-sectional design. It could be valuable to measure the factors at different time points to establish a deeper knowledge regarding how they relate to each other and to both types of motivation for research over time. Secondly, in our study we distinguish two types of motivation for research: intrinsic and extrinsic. SDT distinguishes these two types of motivation in the same way, but a refined version of this theoretical framework shows extrinsic motivation as a spectrum with four types of extrinsic motivation, varying in the quantity of external influences.[26] The items we used to compose the scale to measure extrinsic motivation are mostly related to the external and introjected regulation category. Future research would benefit from refining the concept of extrinsic motivation for research and investigating which factors influence what types of extrinsic motivation. Thirdly, motivation was self-reported and it is unclear whether students will act on their motivation by actually participating in research. Strengths of this study are the large sample size including almost all first-year medical students in our university medical centre and the high reliability of the scales (scales of 3-5 items, $\alpha > 0.77$). This extent of participating students and the large sample size ensures that this study forms a sound base for investigating what influences motivation for research among first-year medical students.

Conclusion

Students' motivation for research could be enhanced by arranging the medical curriculum in a way that continuously stimulates positive self-efficacy beliefs, positive perceptions of research, and curiosity. Besides, we should be aware of and foster students' need for extra challenge by stimulating them to participate in research. Educators should emphasize the importance of conducting research for future clinical practice in such ways that students feel that it is valuable to fulfil their need for challenge by conducting research. Thus, this offers possibilities to catch them young and thereby contributes to the future physician-scientist workforce. The results of this study have shown that students are motivated for research early in medical training and therefore it is our duty to foster these students' motivation.

References

1. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
2. van Eyk HJ, Hooiveld MHW, Van Leeuwen TN, et al. Scientific output of Dutch medical students. *Medical Teacher*. 2010;32(3):231-235.
3. Rosenkranz SK, Wang SY, Hu WD. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15.
4. Moraes DW, Jotz M, Menegazzo WR, et al. Interest in research among medical students: Challenges for the undergraduate education. *Revista Da Associacao Medica Brasileira*. 2016;62(7):652-658.
5. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
6. de Beaufort AJ, de Goeij AFPM. Academic and scientific education in medical curricula in the Netherlands: a programme director's view. *Perspectives on Medical Education*. 2013;2(4):225-229.
7. Dekker FW. Achieving research competences through medical education. *Perspectives on Medical Education*. 2013;2(4):178-180.
8. Kosik RO, Tran DT, Fan APC, et al. Physician Scientist Training in the United States: A Survey of the Current Literature. *Evaluation and the Health Professions*. 2016;39(1):3-20.
9. Solomon SS, Tom SC, Pichert J, Wasserman D, Powers AC. Impact of medical student research in the development of physician-scientists. *Journal of Investigative Medicine*. 2003;51(3):149-156.
10. Harding CV, Akabas MH, Andersen OS. History and Outcomes of 50 Years of Physician–Scientist Training in Medical Scientist Training Programs. *Academic Medicine*. 2017;92(10):1390-1398.
11. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of Investigative Medicine*. 2017;65(5):942-948.
12. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017;6(6):366–368.
13. Goldhamer MEJ, Cohen AP, Bates DW, et al. Protecting an Endangered Species: Training Physicians to Conduct Clinical Research. *Academic Medicine*. 2009;84(4):439-445.
14. Reinders JJ, Kropmans TJ, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. *Medical Education*. 2005;39(2):237.
15. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
16. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
17. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.
18. Morel PA, Ross G. The physician scientist: balancing clinical and research duties. *Nature Immunology*. 2014;15(12):1092-1094.
19. Siemens DR, Punnen S, Wong J, Kanji N. A survey on the attitudes towards research in medical school. *BMC Medical Education*. 2010;10.

20. Varki A, Rosenberg LE. Emerging opportunities and career paths for the young physician-scientist. *Nature Medicine*. 2002;8(5):437-439.
21. Nel D, Burman RJ, Hoffman R, Randera-Rees S. The attitudes of medical students to research. *South African Medical Journal*. 2014;104(1):32-36.
22. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online*. 2013;18.
23. Furtak EM, Seidel T, Iverson H, Briggs DC. Experimental and Quasi-Experimental Studies of Inquiry-Based Science Teaching: A Meta-Analysis. *Review of Educational Research*. 2012;82(3):300-329.
24. Graham MJ, Frederick J, Byars-Winston A, Hunter AB, Handelsman J. Increasing Persistence of College Students in STEM. *Science*. 2013;341(6153):1455-1456.
25. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching*. Dordrecht: Springer Science + Business Media; 2014.
26. Ten Cate TJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. *Medical Teacher*. 2011;33(12):961-973.
27. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
28. Mina S, Mostafa S, Albarqawi HT, et al. Perceived influential factors toward participation in undergraduate research activities among medical students at Alfaisal University-College of Medicine: A Saudi Arabian perspective. *Medical Teacher*. 2016;38:S31-S36.
29. Abu-Zaid A. Research skills: the neglected competency in tomorrow's 21st-century doctors. *Perspectives on Medical Education*. 2014;3:63-65.
30. Green M, Jones P, Thomas Jr JX. Selection criteria for residency: results of a national program directors survey. *Academic Medicine*. 2009;84(3):362-367.
31. Vansteenkiste M, Sierens E, Soenens B, Luyckx K, Lens W. Motivational Profiles From a Self-Determination Perspective: The Quality of Motivation Matters. *Journal of Educational Psychology*. 2009;101(3):671-688.
32. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
33. Robnett RD, Chemers MM, Zurbriggen EL. Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. *Journal of Research in Science Teaching*. 2015;52(6):847-867.
34. Bierer SB, Prayson RA, Dannefer EF. Association of research self-efficacy with medical student career interests, specialization, and scholarship: a case study. *Advances in health sciences education: theory and practice*. 2015;20(2):339-354.
35. Ferla J, Valcke M, Schuyten G. Judgments of self-perceived academic competence and their differential impact on students' achievement motivation, learning approach, and academic performance. *European Journal of Psychology Education*. 2010;25(4):519-536.
36. Berlyne DE. A theory of human curiosity. *British journal of psychology*. 1954;45(3):180-191.
37. Litman JA. Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences*. 2008;44(7):1585-1595.

38. van der Rijst R, Wolfensberger M. Docentopvattingen over de meerwaarde van honoursonderwijs voor het leren van talentvolle en gemotiveerde studenten. *Tijdschrijft voor Hoger Onderwijs*. 2014;31/32(4/1):52-65.

39. Deci EL, Eghrari H, Patrick BC, Leone DR. Facilitating internalization: the self-determination theory perspective. *Journal of personality.* 1994;62(1):119-142.

40. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in health psychology: A user's portfolio. Causal and control beliefs.* Windsor, UK: NFER-NELSON; 1995:35-37.

41. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L, Freeman KE. *Manual for the Patterns of Adaptive Learning Scales (PALS).* Ann Arbor: University of Michigan2000.

42. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International.* 2016:1-8.

43. Imafuku R, Saiki T, Kawakami C, Suzuki Y. How do students' perceptions of research and approaches to learning change in undergraduate research? *International journal of medical education.* 2015;6:47-55.

44. Ribeiro L, Severo M, Pereira M, Ferreira MA. Scientific Skills as Core Competences in Medical Education: What do medical students think? *Int J Sci Educ.* 2015;37(12):1875-1885.

3

Promoting positive perceptions of and motivation for research among undergraduate students to stimulate future research involvement: a grounded theory study

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Abstract

Background: Research is of great value to make advancements within the medical field and, ultimately, offer the best possible patient care. Physician-scientists are key in contributing to the development of medicine, as they can bridge the gap between research and practice. However, medicine currently faces a physician-scientist shortage. A possible solution to cultivate physician-scientists is to engage medical students in research in early phases of medical school. Evidence-based strategies to stimulate positive perceptions of and motivation for research among students could help to enhance research engagement. Consequently, understanding of students' perceptions of and motivation for research is needed. Therefore, this study aimed to identify conditions under which students develop positive perceptions of and motivation for research by answering the following sub-questions: 1) how do first-year medical students perceive research? and 2) which factors contribute to motivation or demotivation for conducting research?

Methods: We conducted a qualitative study with individual interviews using a grounded theory approach, involving 13 purposively sampled first-year medical students at Leiden University Medical Center.

Results: Our results suggest that first-year students are already able to identify many aspects of research. Students elaborated on the relevance of research for professional practice and personal development. Furthermore, our results suggest a relationship between perceptions of and motivation for research. Some perceptions were identical to motivating or demotivating factors to conduct research, like the relevance of research for practice and performing statistics respectively. Other motivating factors were, among others, acknowledgment, autonomy, and inspiring role models. Demotivating factors were, among others, lack of autonomy and relevance, and inadequate collaboration.

Conclusions: Our results contribute to the idea that perceptions of research are related to motivation for research, which offers possibilities for interventions to promote motivation for research by making use of student perceptions of research. Consequently, practical implications to stimulate research engagement in early phases of medical school are provided. Moreover, the results contribute to existing motivational theories like Theory of Planned Behaviour and Self-Determination Theory within this specific domain.

Introduction

Scientific research is of great value to make advancements within the medical field and, ultimately, offer the best possible patient care. In order to practice evidence-based medicine, all physicians should be aware of the newest developments and involve scientific knowledge (e.g. research) in clinical decision making.[1-4] In addition, physicians who actually conduct research (i.e. physician-scientists) are needed as well. Physician-scientists devote a substantial amount of their time to both clinical practice and conducting research, and are thereby key in bridging the gap between science and practice.[5-7]

Unfortunately, the medical field is facing a global shortage of physician-scientists. The current physician-scientist workforce is aging and a decrease in interest to pursue a scientific career is visible in the United States, Canada, and Europe. Recent literature stresses the urgent need to counteract this decline in the physician-scientist workforce.[1,8,9]

Engaging students in research during early phases of medical school could help to acquaint students with research, trigger enthusiasm, and direct more students towards a physician-scientist career.[1,7,10,11]

In order to draw pre-clinical students into research during medical school, knowledge and understanding is needed on how they perceive research and the importance of conducting research for clinical practice. The question arises to what extent these young medical students already comprehend what it is to conduct research and how this relates to clinical practice. Additionally, it is important to know what motivates or demotivates students in their consideration to conduct research.[12]

Studies investigating perceptions of and motivation for research among pre-clinical medical students are scarce. Few studies have focused on perceptions of research and its importance for practice among medical students. For instance, there is evidence that students do not realize the importance of research for clinical practice until the clinical phase of medical training, when they encounter real life problems in patient care.[13] This is in line with previous findings indicating that undergraduate students have a narrow perspective of research and are not aware of the connection between research and practice.[14-16] Nel and colleagues surveyed medical students at the

University of Capetown, and found that 61% of the students had positive attitudes towards research.[17] However, they did not identify the nature of these attitudes. Some of the prior studies also examined motivation for research and suggested that most medical students are motivated to pursue research, but foresee many difficulties and barriers at the same time.[15-17] In one of our earlier studies, we did find students to be highly motivated for research when entering medical school. These results also indicated that pre-clinical students' beliefs about the value of research were important to influence research motivation.[18] In turn, research motivation was related to actual research involvement among undergraduate medical students.[19] This implies that insights into how beginning medical students perceive research could be of great value in directing more medical students towards a physician-scientist career. However, the few conducted studies in this area did not mainly focus on early stages of medical training.

In sum, there seems to be insufficient knowledge about how pre-clinical medical students beginning their medical studies perceive research and how they could be motivated to conduct research. Furthermore, most of the aforementioned studies had a quantitative approach. Since the aim is to engage medical students in research in early phases of medical school, deeper understanding of pre-clinical students' perceptions and motivation regarding research is valuable, for which a qualitative methodology seems imperative. This could help to identify how positive perceptions of and motivation for research can be promoted early on in medical training. In turn, these insights could help to determine possible interventions and the implementation of evidence-based strategies to enhance interest in research among medical students, thereby cultivating future generations of physician-scientists.

Therefore, this study uses a qualitative grounded theory approach to gather in-depth knowledge on how educators can create conditions under which pre-clinical medical students develop positive perceptions of and motivation for research during early phases of medical school, by answering the following two sub-questions: 1) how do first-year medical students perceive research? And 2) which factors contribute to motivation or demotivation for conducting research?

Methods

Context

This study was conducted among one cohort of first-year medical students at Leiden University Medical Center (LUMC). The Netherlands has eight medical schools, which all developed their educational programme in line with the Dutch National Blueprint for Medical Education. The schools offer six years of undergraduate and graduate medical education. In the Netherlands, most students start medical school immediately after graduating from secondary school, at the age of 18-19 years.[20] Consequently, first-year medical students are relatively young and lack any research-related experience.[21] In this study, students' only prior experiences with research were a two-week course at the start of their medical training. In this course, students conducted a small research project and were actively involved in gathering and processing data, formulating their own research question, analysing data and writing a two-page research report.[22]

Research team

The research team comprised of five researchers from different backgrounds. BO is a PhD-candidate in medical education, with a master's degree in Pedagogical Sciences. FB is senior researcher in medical education. MWM is full professor in medical education. DD is full professor of innovative learning arrangements. FD is full professor in undergraduate research in medical education and clinical epidemiology. BO, MWM, DD, and FB have experience with qualitative research approaches and analysis.

Design

We established our research within an interpretivist paradigm, emphasizing the subjective nature in understanding human experiences and creation of reality. According to this paradigm, reality is socially constructed and truth is not grounded within one single objective reality. Rather, there may be multiple ways by different individuals to interpret a single construct or phenomenon.[23] Within the interpretivist paradigm there is an emphasis on valuing the unique views of every individual. Consequently, we used a qualitative grounded theory approach as this eminently suits the aim to create deeper understanding of the unique perceptions of each individual in our study, including purposive sampling and constant comparison. Data was iteratively collected and coded, until saturation and consensus among the first and last author (BO & FB) was reached. We used semi-structured individual interviews to identify and elucidate students' perceptions of and motivation for research.

Participants

All first-year students were informed about the study before the start of a lecture. Students were given the opportunity to apply for participation in this study by signing a registration list, which in total 22 students did. Thereafter, a purposive sampling method (i.e. selective sampling based on the researchers judgment when choosing participants for the study) was applied, aiming to include different types of students in our sample. In our earlier study, all first-year students were surveyed at the beginning of medical school and reported on their research motivation and self-efficacy.[18] Data of the 22 students who signed the registration list from this questionnaire was used in the sampling procedure, aiming to include diverse types of first-year students scoring differently on intrinsic and extrinsic motivation for research, and research self-efficacy. Furthermore, we aimed to include students who were both interested and not interested in entering an extracurricular research-based Honours programme in the second year of education. Lastly, gender and age were included in the selection process.

Between March 2017 and September 2017, BO approached the purposive sampled students by e-mail. Data collection and analysis were performed in an iterative manner, eventually resulting in a total of 13 first-year medical students who were invited and all agreed to participate in our study. This study included 10 female (76.9%) and 3 male (23.1%) students, which is representative for the male/female distribution in the whole cohort (i.e. the total number of first-year students starting medical training in 2016). Students were 18 to 20 years, with a mean age of 19.3 years.

Data collection

BO and FB developed an interview guide (Appendix A), which was checked on followability by discussing it within the research team. BO conducted all interviews, which were audio-recorded and transcribed verbatim line by line. Additionally, a summary was made of the content of the interview, which was then sent to the participant for member checking (i.e. participant check on accuracy). All participants agreed on the content. When participants' quotes were used to illustrate results, participants were again approached to ask for their permission. Every participant agreed on the use of their quotes.

Data analysis

Data analysis was performed alongside data collection in an iterative manner. All interviews were independently coded by BO and FB using a grounded approach. BO and FB discussed their initial findings in the process of analysis, to reach consensus, and built a codebook (i.e. overview of all themes; Appendix B). Three types of coding as described by Strauss & Corbin were used: open, axial, and selective.[24]

Fragments or sentences of the transcript were coded with an 'in vivo approach' (i.e. open coding), followed by interpretative analysis to create overarching categories (i.e. axial coding). Lastly the overarching categories were checked, subsequently followed by the creation of higher-order themes (i.e. selective coding). After the stage of analysis was completed and a codebook with higher-order themes was created, MWM checked followability of the steps that were made in this process. In addition to the completed analysis, BO, FB and MWM independently coded two interviews with the new codebook to test its reliability. All interpretations were then discussed within the entire research team. Data analysis was supported by Atlas-ti 8.0 software (Atlas. ti, GmbH, Berlin, Germany).

Ethical approval

Students gave verbal consent on the audio-recording before the interview and signed an informed consent form after the interview. In compensation for their time, students received a gift certificate of €7.50 to spend in the lunchroom of the LUMC. This study was approved by the Educational Institutional Review Board of the LUMC (IRB reference number: OEC/OG/20180508/2).

Results

We conducted 13 interviews, of which the length varied between 25 and 42 minutes. Inductive thematic saturation (i.e. no new themes emerged) and theoretical saturation of the themes (i.e. no additional data to develop a theme was found, as the researcher sees similar instances over and over again)[25] was reached after 11 interviews, after which we conducted two last interviews to check saturation. Because of the rich data, not all subthemes are discussed in detail. An overview of all themes can be seen in Appendix B.

How do first-year medical students perceive research?

Five higher-order themes emerged: research processes, research goals, research characteristics, research topics, and research requirements.

Students mainly focused on several parts of the *research process*, mentioning creating research questions, choosing a method, gathering data, processing data, creating results, drawing conclusions, and reporting outcomes. On the one hand, some students had the perception that research consisted of single, specific parts, reflecting a relatively narrow definition of research.

> [Research is] the whole day in the lab or doing your best to persuade people to participate in your research. – S1

On the other hand, in some cases students did connect multiple phases of conducting research, creating a bigger picture of what the process of research entails.

> [Research] exists out of, for a large part, pre-work; thinking about what you want to study, how you are going to do that, methods, participants or something like that. And if you have devised the entire research, then you will carry it out, for instance by interviewing like this I think, it depends on the kind of research you're performing, if you will do tests or something like this, and then thereafter it exists out of processing all your data, of course, drawing conclusions from it, and writing an article about it. – S12

However, students tended to focus on more than only these concrete aspects of doing research. They also mentioned *research goals*, reflecting on the importance of research for society and healthcare in general. For instance, the valuable role research plays in creating new knowledge or refining existing knowledge, and thereby the improvement of understanding in general.

> Some fundamental studies are done for understanding, a sort of, contribution to the general understanding of how something works. – S1

Furthermore, students had more specific goals of research in mind as well, emphasizing the medical context. In particular, students elaborated on developing and improving medicines or illness treatments, but also on improving the organisation within the whole hospital. Moreover, students also discussed the role research could play in improving education, which in turn helps to educate and deliver better physicians.

> I think that with research, on the one hand, we can gather more knowledge on the emergence of diseases and the human body, but on the other hand we can treat these

> diseases better or even find a cure. But I also think that, within medical healthcare, there also exists research into, for instance, collaboration between people and the best way to shape a hospital, or the best way to work within teams. – S7

Perceptions of research were also illustrated in different *characteristics* students assign to research. Students tended to concentrate on negative aspects, like the hard and intensive character of research. The idea that conducting research is hard is mostly related to the lack of or difficulty in finding results.

> I think you need to have perseverance [to conduct research], because nine out of ten times you will get a result you actually did not want to have. – S13

Moreover, research is seen as an intensive and complex activity in which different tasks need to be combined, the researcher has many different appointments and several obligations like following rules and administrative work.

> You need to be able to make appointments, very many appointments, and you need to make sure to work on your own research, you must write a text, all that taken together, you need to arrange that in a good way to prevent double appointments and to prevent that, because of all the appointments, you can't write. So, yeah… it seems like a busy thing to me. – S4

Students also commented on *research topics,* namely healthcare, prevention, and organization.

> You have health-promoting, which predominantly focuses on prevention areas of research, but you also have research into different diseases and mechanisms. But I think that you can also study the way an organisation works and how they collaborate within medical contexts. – S3

The last higher-order theme that emerged, is one that is not directly linked to research itself. The first-year medical students also described *research requirements*, illustrating conditions that researchers must meet in order to actually perform their research. Students emphasized the importance of collaboration, finance, and ethical approval.

> A researcher is not only doing the research itself, but also busy with financing, arranging to be able to work with other people. I think that next to the research itself, research entails more, a researcher does more than just the research on its own. – S7

Which factors contribute to motivation for conducting research?
Students reported motivators for research from the perspective of personal benefit. For instance, they would be motivated to do research because it would contribute to their *personal development*. Students mentioned a lack of academic training and challenge in the curriculum, and the need to delve into certain topics instead of just learning facts and receiving knowledge in the broadest sense. Students saw research as a possibility to delve into a topic and learn academic skills at the same time.

> I think it [research] is very interesting and I see this as a part of my academic training, which is missing in general medical training in my opinion. – S3

Subsequently, students also mentioned that they would be motivated to do research to comply with their personal needs like their *curiosity*, *need for challenge*, and need for *variety*.

> I just want to have some extra challenge, because medical training on itself is just learning, learning, learning. And if you have something next to that more directly linked to practice and you see where you can end up, that motivates me. – S13

Moreover, students felt the need to *contribute to knowledge and patient care*. They mentioned that it would be motivating for them to conduct research if their research actually meant something for science or healthcare. Students described the process of creating or revising knowledge as motivating, but they mostly elaborated on what research could mean for patients. They related research to, for instance, helping more patients, and finding cures for diseases. These outcomes of research were highly motivating for students.

> Especially when I hear that some things are still unknown, where no solutions are available, for instance multiple sclerosis (MS). My aunt has MS, and to see her like that every day, not being able to walk… and that there is no solution for that. In my opinion, there needs to come a cure for that. – S4

Students also mentioned that *different parts of conducting research* seemed fun, which in turn motivated them to conduct research. They said they especially liked seeing and creating results. Moreover, content was important and the writing process was very appealing to them. The social aspects of research, like *collaboration*, were motivating as well.

> Especially the collaboration with others appeals to me, I like to collaborate with others. And the results at the end, that you made something beautiful together what turns out to be a big part of your career. – S4

Furthermore, reading or hearing about research related work of others and their enthusiasm is inspiring for students (i.e. *inspiring role models*) and contributes to their motivation for research.

> I had a chemistry teacher and he investigated a very specific topic, a specific protein. And he was so, well a specialist I suppose, very enriched, that he could transfer that in a beautiful way. And actually, I was kind of, very, impressed with that [. . .]. I can get inspired by that. – S10

Students also described the importance of research bringing them external rewards, such as *acknowledgments*. Students wanted to be able to show that they actually did research and mentioned publications as a possible reward of, and thereby motivating factor for, research. Furthermore students wanted opportunities to build a network and to distinguish themselves from others, and were motivated for research because it could help them in their future career steps, like securing a competitive residency spot.

> I think that it depends on what kind of specialism I want to get in. And what is expected of you with regard to research. I have to be honest, it is not a really romantic reason, but yes… – S1

Which factors contribute to demotivation for conducting research?

Students especially focused on the *content* of research itself and different demotivating parts of conducting research. For instance, research topic could play a large part in demotivating students to conduct research.

> With regard to content, it could demotivate me very much I think. Imagine that this is a topic I am not very curious about, I think when I delve into it, really in detail, that I lose all my curiosity. – S1

Furthermore, in a broader sense, students found the difficulties of doing research demotivating. Students especially mentioned *processing of data* and *statistics* as uninteresting. These activities within research could really hold students back in their possible choice to conduct research.

> All that gathering of data, SPSS. It has become something I fear […]. I think it is terrifying that I don't know where to begin. – S12

It would also be demotivating for students when their contribution to both research and society is small, for instance when their research is not used in practice. Furthermore, students acknowledged that *disappointing results* are plausible, but at the same time they strongly felt like this would demotivate them for conducting research.

Moreover, students described a *lack of autonomy* as demotivating. Especially when students have no choice in what kind of research they perform and when students have to comply to a variety of rules, they did not want to conduct research.

> When research would be imposed, than I really would not, like here is a topic, go do your research. That would be very demotivating. – S8

At the same time, a *lack of support* could be demotivating as well. Students did not want to have the feeling they are doing research alone. It seems like a balance between autonomy and support suits students best. Subsequently, students mentioned an *inadequate atmosphere or collaboration* within the research group to be very discouraging as well.

> When I would be part of a research group with a very bad atmosphere, or when people are not willing to answer a question or help you, that seems very demotivating to me. And that has nothing to do with the research itself, but really the collaboration […]. So I think, mainly, when having the feeling you are alone, without the possibility to call for help, that seems very difficult to me. – S7

Discussion

We qualitatively explored first-year students' perceptions of research. Furthermore, we determined motivating and demotivating factors for conducting research. The pre-clinical students differed greatly in their perceptions of and motivation for research, which resulted in rich data with many different aspects. Within this data, some tensions emerged. On the one hand, students were able to describe important steps within the research process. On the other hand, students did tend to emphasize that certain parts of the research process, such as gathering of data and statistical analyses, were not appealing to them. Moreover, students perceived research as useful for clinical practice and personal development. However, students seemed to have negative perceptions in terms of what conducting research actually entails, and emphasized its difficulties and negative aspects.

In-depth analysis elucidated a variety of higher-order themes related to perceptions of research. In contrast to our results, a previous study of third-year medical students' perceptions concluded that students had a narrow definition of research in the beginning of their third year.[14] Our results illustrate that *first-year undergraduate students* can already have broad perceptions of research. A possible explanation for this could be that an authentic learning situation at the beginning of medical training in which pre-clinical students conduct a small research project contributes to students' knowledge of what research entails and its possibilities for clinical practice.[22] This is in line with the study by Imafuku and colleagues, showing that students' initial narrow definition of research was somewhat broadened after their first research experiences.[14]

Going beyond our research questions, our results suggest a relation between perceptions of and motivation for research. This is, among others, illustrated by students' elaboration on various research goals, mainly focusing on its direct association with clinical practice and patient care. For instance, students viewed research as a way to make progress, develop medicine, create better physicians, and improve patient experiences. This direct association with practice contributed to students' assumption that research is useful, emerging as a sub-theme of research characteristics. Additionally, these kind of topics were also identified by students as motivating, resulting in the theme 'contributing to knowledge or patient care' (Appendix B). This implies that the social value of research is also something that could motivate students to subsequently conduct research. Therefore, medical schools may create conditions to raise awareness of the usefulness of research for clinical practice early in the curriculum. This could help pre-clinical students to develop positive perceptions of and motivation for research in early stages of medical education.

Nonetheless, there also seems to be a relation between perceptions and demotivation to conduct research. For instance, students tended to think that the biggest part of conducting research entails processing data and performing statistical analyses. Moreover, processing data and statistics also emerged as two subthemes of demotivating factors. This contributed to their idea that research is performed within a unilateral work environment (Appendix B).

Previous studies showed that student perceptions of research are open to change.[14,26] By targeting and adjusting unrealistic perceptions, such as the notion that research is merely statistics, motivation for research can be influenced. By acquainting pre-clinical students with the broader nature of conducting research, their perceptions can be altered. For example, students explicitly mentioned that writing is a fun aspect of research that contributed to their motivation. Therefore, educators could explicitly mention that this is part of the research process as well and that writing relies on creating results, for which statistical analysis could be necessary. Furthermore, statistics is unknown for many students and may seem frightening. Students are more inclined to pursue an activity when they feel confident about their capability in that domain (i.e. self-efficacy), and mastery of an activity leads to higher self-efficacy beliefs.[27] Students in pre-clinical phases of medical training lack experience with statistical analyses. Making statistics less ambiguous could also be a solution to motivate more students for conducting research. By letting students apply statistics directly to authentic research questions, even in their first undergraduate year, they can experience the relevance of statistics for creating results and finding answers to important questions. Through repeated practice with statistics, they can master it and self-efficacy beliefs may be enhanced.

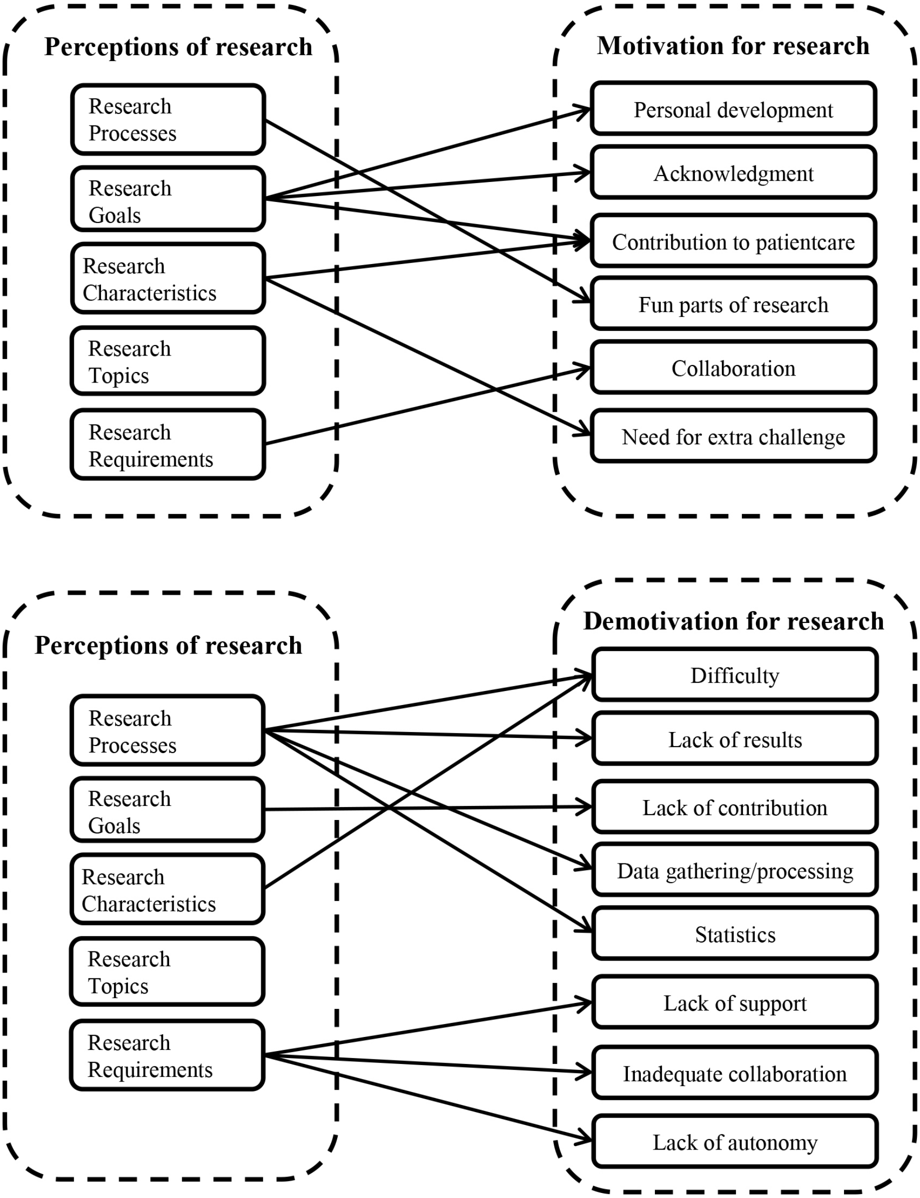

Figure 1. Main themes regarding student perceptions of research and its relations with motivating and demotivating aspects of conducting research

Despite the grounded theory approach, parallels between the outcomes of our study and existing theories were visible. When students mentioned perceptions of research that also emerged as motivating or demotivating factors, they already gave an evaluation, connecting a favourable or unfavourable qualification to their perception. This is, for example, illustrated in perceptions of research as primarily being statistics, which students saw as a negative aspect. This seems to be in line with and substantiated by the Theory of Planned Behaviour (TPB). TPB states that attitudes are a prerequisite for motivation, which in turn is related to certain behaviours. According to TPB, attitudes are perceptions of a certain behaviour including the evaluation of the behaviour (i.e. favourable versus unfavourable).[28] This lends support to the idea that perceptions linked to motivation within our data are equal to 'attitudes' mentioned as an antecedent for motivation in TPB. Consequently, this also provides evidence for the idea that if perceptions of research are changed, motivation can be influenced as well. In turn, this offers opportunities to develop interventions and implement evidence-based strategies aiming to target student perceptions to motivate more students for research in early stages of medical school.

Our findings regarding autonomy, support, and development that are a necessity for student motivation are in accordance with and substantiated by the Self-Determination Theory (SDT). SDT states that motivation is influenced by three basic psychological needs: autonomy, relatedness, and competence.[29] These basic psychological needs are in line with the themes that emerged from our data. However, our data imply that influencing motivation entails more than only autonomy, relatedness, and competence (Figure 2). A sense of relevance, e.g. being able to contribute to patient care, seems to have a major influence on motivation as well. Moreover, need for challenge and curiosity were also named as motivational factors. In addition, inspiring role models could be prerequisites for motivation as students emphasized they were inspired and became motivated by the work of others. Not only by reading scientific articles, but also by hearing about research related work from enthusiastic researchers. This provides insights in practical implications, as many educators conduct research as well and can communicate their own work in an enthusiastic way towards students during lectures or seminars. Providing students with opportunities to read articles and get acquainted with work of others seems to be a good possibility to contribute to their motivation as well. When looking at our data, neither TPB nor SDT seem to comprehend all prerequisites for motivation. Hence, our study could contribute to the expansion of existing motivational theories like TPB and SDT, as illustrated in figure 2.

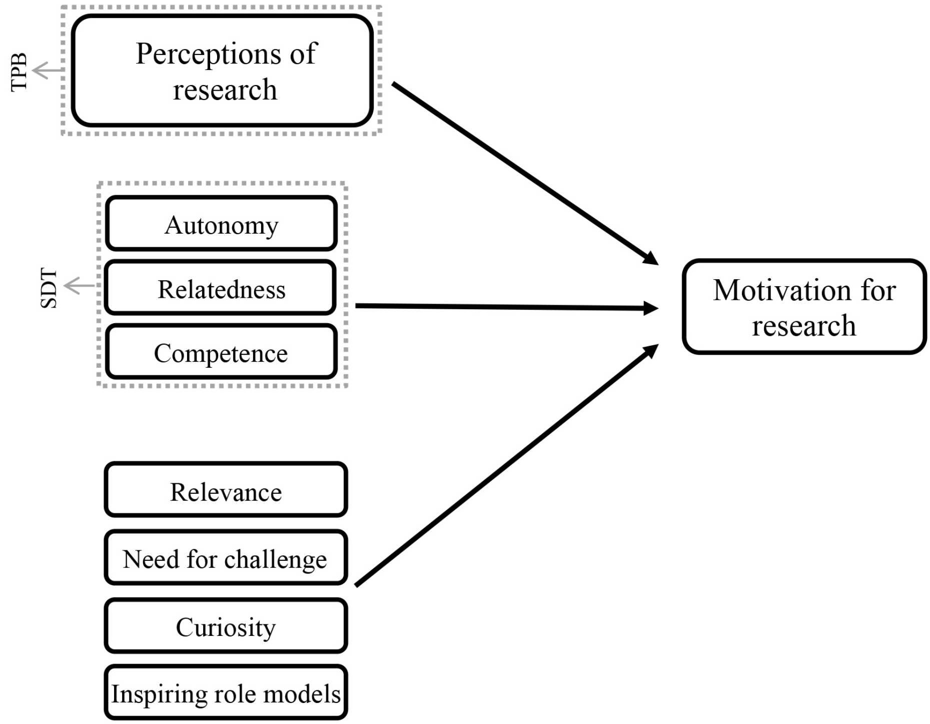

Figure 2. Prerequisites of motivation according to TPB and SDT, added by prerequisites as identified in our study

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Practical implications

In order to answer the fundamental question how conditions can be created under which students develop positive perceptions of and motivation for research in early stages of medical school, the emerged themes within the motivating and demotivating factors play a crucial role. Next to embedding research related courses in the curriculum and using educators as inspiring role models, our study provides other practical implications as well. Based on our results, it seems beneficial to create conditions in which students experience autonomy and the ability to work independently. In order to motivate students to conduct research, this seems to be key. Therefore, providing students with research experiences should be designed in such a way that students feel they are in control of their own research projects. Practically, this could be done by giving students multiple options regarding, for instance, the topic of their research. Furthermore, students could be stimulated to take a leading role in the implementation of their research. This not only contributes to feelings of autonomy, but is also related to the effective educational approach of 'learning by doing' as has been advocated by many throughout the years.[30-35] This is also reflected in our results, as our pre-clinical students mentioned that they would be motivated for research if they get the opportunity to actually perform research themselves. This stresses the need for more active learning approaches, providing students with research experiences in authentic learning situations in order to motivate more students for research.

Students were also in need of collaboration and wanted the possibility to rely on more experienced researchers. An inadequate atmosphere and lack of support are demotivating factors for students. This indicates the need for a balance between autonomy and support. In practice, this could mean that conditions need to be created in which students are able to become leaders of their research project, while a more experienced researcher closely monitors their development and provides support when needed. Furthermore, students indicated they were motivated when there were possibilities to develop competencies and receive acknowledgment or rewards. It would be beneficial to offer students the chance to work on their learning goals and mastery of research activities. Moreover, stimulating them to present their work in the form of publications or presentations at scientific meetings could enhance motivation for research and confidence.[36] In this way, students feel acknowledged for their work and are able to build a network. This should be embedded within education and explicitly communicated to students.

Limitations and strengths

This study was conducted in one medical school, which may have implications for generalizability to other contexts. However, to the best of our knowledge, our study is the first to address perceptions of and motivation for research among medical students in early phases of medical training. We used qualitative methodology with an open and grounded approach, which is why we believe we elucidated actual student perceptions without steering towards certain outcomes. Furthermore, we applied thorough purposive sampling by using data of the same cohort of students in an earlier administered questionnaire in order to select a representative and diverse sample. We believe that these measures contributed to the great amount and variety of data in our study. Our findings provide new insights in the way beginning medical students perceive research, as well as factors promoting their motivation to conduct research. The findings contribute to both theory and practice, and may provide guidance for future quantitative research in which the generated hypotheses can be tested.

Moreover, our results are in line with multiple existing theories. Therefore, we expect that our results may be applicable to other situations (e.g. educational programmes within other countries, (post)graduate medical students) and may apprise education and studies in other contexts.

Future research

It would be beneficial to study perceptions of and motivation for research in different educational programmes and contexts in order to provide even more insights into how students' positive perceptions and motivation for research could be promoted. Also, it would be an interesting future research avenue to conduct this study among medical students in other countries. Furthermore, it would be interesting to investigate the development of medical students' perceptions of and motivation for research during medical training, in which they gradually engage in clinical practice. Our data suggested a relation between perceptions of and motivation for research, future research could be undertaken to investigate this hypothesis.

Conclusions

Our study demonstrated that first-year students have broad perceptions and definitions of research. Additionally, a broad range of motivating and demotivating factors to conduct research were identified. Our results contribute to the idea that perceptions of research are related to motivation for research, which offers possibilities for interventions and promoting motivation for research through student perceptions. Furthermore, we identified relevance, curiosity, need for challenge, and inspiring role models as prerequisites for motivation in addition to perceptions as stated by TPB and autonomy, relatedness, and competence as stated by SDT. Consequently our study may contribute to expanding existing motivational theories like TPB and SDT. Moreover, conditions were identified under which pre-clinical students develop positive perceptions of and motivation for research during early phases of medical school in order to engage more students in research and make the first step to cultivate future physician-scientists.

References

1. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
2. Dekker FW. Achieving research competences through medical education. *Perspectives on Medical Education*. 2013;2(4):178-180.
3. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching*. Dordrecht: Springer Science + Business Media; 2014.
4. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
5. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017.
6. Harding CV, Akabas MH, Andersen OS. History and Outcomes of 50 Years of Physician-Scientist Training in Medical Scientist Training Programs. *Academic Medicine*. 2017.
7. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017;65(5):942-948.
8. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
9. Hall AK, Mills SL, Lund PK. Clinician-Investigator Training and the Need to Pilot New Approaches to Recruiting and Retaining This Workforce. *Academic Medicine*. 2017.
10. Reinders JJ, Kropmans TJ, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. *Medical Education*. 2005;39(2):237.
11. Goldhamer MEJ, Cohen AP, Bates DW, et al. Protecting an Endangered Species: Training Physicians to Conduct Clinical Research. *Academic Medicine*. 2009;84(4):439-445.
12. Seymour E, Hunter AB, Laursen SL, Deantoni T. Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education*. 2004;88(4):493-534.
13. Rosenkranz SK, Wang SY, Hu WD. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15.
14. Imafuku R, Saiki T, Kawakami C, Suzuki Y. How do students' perceptions of research and approaches to learning change in undergraduate research? *International journal of medical education*. 2015;6:47-55.
15. Murdoch-Eaton D, Drewery S, Elton S, et al. What do medical students understand by research and research skills? Identifying research opportunities within undergraduate projects. *Medical Teacher*. 2010;32(3):e152-e160.
16. Burgoyne LN, O'Flynn S, Boylan GB. Undergraduate medical research: the student perspective. *Medical Education Online*. 2010;15(1):5212.
17. Nel D, Burman RJ, Hoffman R, Randera-Rees S. The attitudes of medical students to research. *South African Medical Journal*. 2014;104(1):32-36.
18. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education*. 2018;7:248-255.

19. Ommering BWC, van Blankenstein FM, Wijnen-Meijer M, van Diepen M, Dekker FW. Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. *BMJ open*. 2019;9(7):e028034.
20. Wijnen-Meijer M, Burdick W, Alofs L, Burgers C, ten Cate O. Stages and transitions in medical education around the world: clarifying structures and terminology. *Medical Teacher*. 2013;35(4):301-307.
21. Ten Cate O. Medical education in the Netherlands. *Medical Teacher*. 2007;29(8):752-757.
22. Ommering BWC, van Diepen M, van Blankenstein FM, de Jong PGM, Dekker FW. Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students. *Med Teach*. 2020.
23. Cohen L, Manion L, Morrison K. *Research methods in education*. Routledge; 2013.
24. Strauss A, Corbin JM. *Basics of qualitative research: Grounded theory procedures and techniques.* Sage Publications, Inc; 1990.
25. Saunders B, Sim J, Kingstone T, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & Quantityt*. 2018;52(4):1893-1907.
26. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International*. 2016:1-8.
27. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
28. Ajzen I. The theory of planned behavior. *Organizational behavior and human decision processes.* 1991;50(2):179-211.
29. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
30. Dewey J. *Democracy and education*. Mineola, NY: Dover Publications, Inc. ; 2004.
31. Janmaat VT, Kortekaas KE, Moerland TM, et al. Tutored Learning: An Effective Way for Students to Benefit Research by Critical Appraisal. *Medical Science Educator*. 2013;2(23):269-277.
32. Jenkins A. *Reshaping teaching in higher education: Linking teaching with research.* Psychology Press; 2003.
33. Lazonder AW, Harmsen R. Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research*. 2016;86(3):681-718.
34. Healey M, Jordan F, Pell B, Short C. The research–teaching nexus: a case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International*. 2010;47(2):235-246.
35. Harland T. Teaching to enhance research. *Higher Education Research & Development*. 2016;35(3):461-472.
36. Walkington H, Hill J, Kneale PE. Reciprocal elucidation: a student-led pedagogy in multidisciplinary undergraduate research conferences. *Higher Education Research & Development*. 2017;36(2):416-429.

4

Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement

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Abstract

Objectives: The medical field is facing a physician-scientist shortage. Medical schools could contribute to developing physician-scientists by stimulating student involvement in research. Studies have examined motivation for research as a key parameter of success. However, previous studies did not investigate if students act upon their self-reported motivation. The aim of this study is to examine if motivation for research of medical students is related to actual research involvement. Furthermore, this study distinguishes intrinsic and extrinsic motivation for research and aims to investigate if type of motivation matters in the relation between research motivation and involvement.

Design and Setting: Prospective cohort study in which students were surveyed at the start of medical school and reported intrinsic (IM) and extrinsic (EM) motivation for research, self-efficacy, perceptions of research, and curiosity on a 7-point Likert scale. One year later, students involved in research were identified. Logistic regression was used to examine influences of IM and EM on research involvement.

Participants: All undergraduate medical students starting at one medical school in the Netherlands in 2016. In total, 315 out of 316 students participated (99.7%), of whom 55 became involved in research (17.5%).

Results: Students with higher levels of IM were more often involved in research (OR = 3.4; 95%CI = 2.08 - 5.61), also after adjusting for gender, age, extracurricular high-school activities, self-efficacy, perceptions, and curiosity (OR = 2.5; 95%CI = 1.35 - 4.78). Higher levels of EM increased the odds of research involvement (OR = 1.4; 95%CI = 0.96 - 2.11). However, the effect of EM disappeared after adjusting for the above mentioned factors (OR = 1.05; 95%CI = 0.67 - 1.63). Furthermore, the effect of IM remained after adjusting for EM, whereas the effect of EM disappeared after adjusting for IM.

Conclusions: Our findings suggest that type of motivation matters and intrinsic motivation influences research involvement. Therefore, intrinsic motivation could be targeted to stimulate research involvement and could be seen as a first step towards success in fostering the physician-scientist workforce.

Introduction

Research is key in the advancement of medicine, life-long learning, and offering the best possible patient care.[1,2] Concerns have been raised regarding the gap between research and clinical practice, emphasizing the small quantity of clinical problems that are translated into research on the one hand, and the lack of incorporating new scientific knowledge into clinical practice on the other hand.[3-5] Physicians who are involved in both clinical practice and research (i.e. physician-scientists) play an essential role in this process of translational research. Physician-scientists have the unique ability to move from 'bench to bedside', combining both clinical and scientific insights. Therefore, physician-scientists can bridge the gap between research and practice.[3-7] The importance of physicians who conduct research is reflected in the adoption of this competency in frameworks like the Canadian Medical Education Directives for Specialists (CanMEDS) and the U.S. Accreditation Council for Graduate Medical Education (ACGME).[8,9] Furthermore, different programmes have been initiated to secure a pathway in which medical graduates can build scientific careers, like internationally known MD-PhD programmes and, for instance, the NIHR Academic Clinical Fellowship scheme in the United Kingdom.[10]

However, concerns have also been raised about the future of academic medicine. Despite the well-known and increasing importance of physician-scientists, the medical field is facing an international shortage of physician-scientists. A declining interest in academic careers combined with an ageing physician-scientist workforce poses a serious threat.[7,11-1919]

Inspiring medical students for a research oriented career at an early stage has been suggested as a possible solution to reverse the decline in physician-scientists. Stimulating engagement of medical students in research during medical school could contribute to the development of future physician-scientists.[12,14,20] This is reflected in the emergence of research-related courses in the curriculum and extracurricular research programmes within many medical schools, as a means to provide students with research experiences.[4,7,15,16,21-24] Active participation of students in research could help to recognize and develop talent. Moreover, it could trigger enthusiasm and motivation among medical students.[25-27]

Previous studies have suggested that student participation in research is associated with involvement in research during professional practice.[12,24,28,29] Furthermore, many motivational theories describe prerequisites of motivation. For instance, Social Cognitive Theory emphasizes that motivation is based on self-efficacy beliefs (i.e. the beliefs someone has about their ability to accomplish a certain outcome),[30] and the Self-Determination Theory (SDT) describes autonomy, competence, and relatedness as three basic psychological needs fundamental to intrinsic motivation (i.e. doing a certain activity out of pure interest or enjoyment).[31] Next to intrinsic motivation, SDT introduces extrinsic motivation (i.e. doing a certain activity because it is rewarding) as well. However, according to SDT, intrinsic motivation is of better quality as it promotes deep learning, academic performance, and feelings of wellbeing.[31] Subsequently, previous studies investigated motivation as an outcome measure, describing student motivation or interest for research as the ultimate outcome.[32-34] For instance, Vereijken and colleagues investigated interest and motivation for research after a curriculum change to strengthen research integration with education and showed that students' motivation for research increased when research was integrated more in the curriculum.[35] Moreover, in our previous study we established that students are highly motivated for research when entering medical school and that self-efficacy beliefs, perceptions of research, and curiosity are important factors that influence motivation for research.[36]

The question arises whether it is legitimate to pose motivation for research as a key parameter of success and if students act upon their self-reported motivation for research. If the preeminent goal is to cultivate the next generation of physician-scientists by stimulating students' motivation for research, it is important to examine whether motivation for research leads to actual research involvement. If so, stimulating motivation for research could be seen as a first step to cultivate future physician-scientists. However, little if any attention has been paid to whether motivation for research actually results in getting involved in research.

Therefore, the aim of this study is to investigate whether motivation for research is a first step towards success in fostering the physician-scientist workforce, by examining to what extent intrinsic and extrinsic motivation for research among first-year medical students influences involvement in research during medical school.

Methods

Participants

This prospective cohort study followed all medical undergraduate students starting medical school in 2016 at Leiden University Medical Center (LUMC). All first-year medical students were asked to participate in this study and surveyed at the start of medical school in 2016. Data was collected on involvement in research in their second year of medical school. In the Netherlands, eight medical faculties (i.e. academic hospitals) provide students with medical training. All faculties developed their educational programme in line with the Dutch National Blueprint for Medical Education. The faculties are comparable in the structure of their educational programme, with six years of undergraduate medical study. The LUMC is one of eight academic hospitals.[37]

Materials and definitions

In order to survey first-year medical students, we modified existing and validated scales,[31,38-42] by adjusting them to the medical education setting and focusing on research activities. The 7-point Likert type questionnaire (Appendix C) consisted of 33 items with a range from 1 (totally disagree) to 7 (totally agree).

The independent variable *motivation for research* was divided into two types of motivation: intrinsic and extrinsic motivation. Intrinsic motivation was defined as being motivated to conduct research out of one's own interest or enjoyment. Extrinsic motivation was defined as being motivated to conduct research because it is rewarding, for instance for future training and career opportunities. We measured intrinsic motivation with five items based on the Interest/Enjoyment Scale and extrinsic motivation with four items based on the Value/Usefulness Scale. Both scales are part of the SDT questionnaires.[31,38]

The dependent variable *involvement in research* was operationalized as the enrolment of students in the research-based Honours programme of the LUMC and extracurricular research. The LUMC Honours programme is a voluntary, extracurricular programme with a fundamental orientation towards research. The programme starts in the second year of medical school and has a duration of two years. The programme is open to every medical student, as the selection is mainly based on self-selection without institutional selection criteria.[22] In addition, information from a questionnaire administered within the same cohort at the start of the second year (response rate 95%) was used to identify students who were conducting research on a voluntary basis outside of the LUMC Honours programme. In this questionnaire, students were asked if they were conducting research themselves. All students who were not enrolled in the Honours programme but still answered this question with a 'yes' were approached by the first author to discuss the nature of their research activities. Any kind of research performed by a student within a medical department of the hospital was deemed eligible. Thus, students were seen as 'involved in research' if they 1) enrolled in the research-based Honours programme or 2) were identified as involved in voluntary research activities outside of the regular curriculum and the research-based Honours programme.

Self-efficacy, perceptions of research, and curiosity were measured in the questionnaire and included in this study as possible confounders. We measured self-efficacy with nine items focusing on general self-efficacy, academic self-efficacy, and research self-efficacy. Of these nine items, three items were based on the Dutch General Self-Efficacy scale,[39] three items were based on the Academic Efficacy Scale,[40] and three items regarding research self-efficacy were self-developed and designed based on the previous six self-efficacy items. We measured perceptions of research with five items of the students' beliefs about the value of research and learning scale from the Student Perception of Research Integration Questionnaire (SPRIQ).[41] Lastly, we measured curiosity with ten items of the Epistemic Curiosity Scale.[42]

Procedure

After composing and adjusting the questionnaire, we translated the questionnaire from English to Dutch by using the forward and backward translation procedure. We pretested the questionnaire on ten second-year medical students, after which we made minor adjustments to two items. At the start of medical training in 2016, all first-year medical students were approached by the first author in a workgroup session. It was explained to students that the study investigated scientific training during medical school and that participation was voluntary. Furthermore, students were informed that all data would be used for research purposes and would be processed anonymously. This study was approved by the educational institutional review board of Leiden University Medical Center: IRB reference number OEC/OG/20161108/2 and by the ethical review board of the Netherlands Association of Medical Education: reference number 952.

Analysis

We used descriptive statistics to report gender, age, and previous educational experiences of the students. We calculated Cronbach's alpha to estimate the reliability of the scales. We calculated mean scores for intrinsic motivation, extrinsic motivation, self-efficacy, perceptions of research, and curiosity (range 1 to 7). If students answered more than 70% of the items of a scale, we applied mean substitution for missing values (applied in 3.5% of the students). To assess the influence of intrinsic and extrinsic motivation for research at the start of medical school (T1) on involvement in research in the second year of medical school (T2), we used univariate logistic regressions. Furthermore, we assessed the same relation correcting for potential confounding factors gender, age, extracurricular high school activities, self-efficacy beliefs, perceptions of research, and curiosity at T1 by using multivariate logistic regression. We present 95% confidence intervals. We analysed all data using IBM SPSS Statistics version 23 for Windows.

Patient and public involvement

No patients involved.

Results

Of the 316 approached students, 315 students participated in this study (99.7%). This study consisted of 90 male (28.6%) and 225 female (71.4%) participants with a mean age of 18.57 years ($SD = 1.37$). Of the 315 students, 32 students (10.1%) participated in extracurricular high school activities that were not directly related to research (e.g. pre-university college or following additional courses). Baseline scores of students on motivation, self-efficacy, perceptions of research, and curiosity can be found in Table 1. Cronbach's alpha was calculated for the scales of the questionnaire and ranged from .77 to .88.

Table 1. Baseline characteristics of first-year medical students (n = 315), reliability, and sample items of the scales [a]

	Mean	SD	Min	Max	Cronbach's α	Sample item
Intrinsic Motivation	5.49	.73	2.8	7.0	.79	Doing research is fun
Extrinsic Motivation	5.66	.80	3.0	7.0	.77	I think doing research improves my chances for my preferred residency spot
Self-efficacy	5.25	.73	3.1	6.9	.88	I feel I am competent enough to do research
Perceptions of research	5.53	.81	2.4	7.0	.83	It is important for medical professionals to have scientific skills
Curiosity	5.13	.81	2.9	7.0	.87	I enjoy investigating new ideas

[a] Based on a 7-point Likert scale

In total, 55 students (17.5%) were identified as involved in research in their second year of medical school: 50 were enrolled in the research-based Honours programme and five were involved in voluntary research activities outside of the programme (i.e. (bio)medical research). Logistic regression analyses indicated that first-year students with higher scores on intrinsic motivation for research were more often involved in research in their second year (OR = 3.4; 95% CI = 2.08 - 5.61). This means that for every point a student scores higher on intrinsic motivation, the odds of involvement in research were 3.4 times higher. This effect remained quite strong and significant after adjusting for gender, age, extracurricular high school activities, self-efficacy, perceptions, and curiosity (OR = 2.5; 95% CI = 1.35 - 4.78). First-year students with higher levels of extrinsic motivation for research were more often involved in research as well (OR = 1.4; 95% CI = 0.96 - 2.11). However, this effect disappeared after adjusting for gender, age, extracurricular high school activities, self-efficacy, perceptions, and curiosity (OR = 1.05; 95% CI = 0.67 - 1.63). An overview can be found in Table 2. In addition, the effect of intrinsic motivation for research remained strong and significant after adjusting for extrinsic motivation for research (OR = 3.4; 95% CI = 2.02 - 5.71). The opposite was found regarding extrinsic motivation for research, of which the effect disappeared completely after adjusting for intrinsic motivation (OR = 1.02; 95% CI= 0.67 - 1.56). Thus, extrinsic motivation for research does not add to the effect of intrinsic motivation for research on research involvement.

Table 2. Effect of intrinsic and extrinsic motivation for research in the first year on performing research in the second year of medical training: crude and adjusted for age, gender, extracurricular high school activities, self-efficacy, perceptions of research, and curiosity

	Intrinsic Motivation		Extrinsic Motivation	
	OR	95% CI	OR	95% CI
Crude	3.418	2.083 - 5.606	1.426	0.963 - 2.110
Adjusted for age and gender	3.433	2.084 - 5.655	1.415	0.953 - 2.100
Idem + extracurricular high school activities	3.403	2.046 - 5.660	1.491	0.994 - 2.235
Idem + self-efficacy	3.341	1.863 - 5.992	1.297	0.850 - 1.979
Idem + perceptions of research	2.790	1.509 - 5.160	1.105	0.714 - 1.710
Idem + curiosity	2.536	1.346 - 4.778	1.046	0.671 - 1.631

Discussion

Intrinsic motivation for research at the start of medical school has a strong effect on research involvement in the second year, also after adjusting for gender, age, extracurricular high school activities, self-efficacy beliefs, perceptions of research, and curiosity. Extrinsic motivation influences research involvement on its own, but this effect disappeared after adjusting for the abovementioned factors. Furthermore, there is a strong effect of intrinsic motivation, which remains after adjusting for extrinsic motivation, while the effect of extrinsic motivation disappears after adjusting for intrinsic motivation.

Our findings suggest that the type of motivation plays a crucial role in whether students act upon their motivation and become involved in research. The findings are in line with the Self-Determination Theory (SDT), which, in contrast to most motivational theories, emphasizes the quality of motivation instead of the quantity of motivation. SDT states that higher levels of motivation are not necessarily related to more advantageous outcomes if the motivation is of poor quality. Extrinsic motivation is not fully internalized (i.e. doing a certain activity because of external pressure or for a reward), whereas intrinsic motivation is self-determined (i.e. doing a certain activity out of pure interest). Thus, according to SDT, intrinsic motivation is of best quality and the optimal type of motivation. Moreover, intrinsic motivation improves academic performance and overall wellbeing.[31,43,44] Our results contribute to the idea that motivation is not one single construct and that intrinsic motivation yields the most desirable outcomes. Furthermore, our findings on the importance of intrinsic motivation are also in line with a previous study regarding career persistence in academic medicine. One of the major themes in a scoping review focusing on factors that influence career progression among clinical academics was intrinsic motivation among these professionals.[45]

Multiple studies within the medical context investigated possible reasons for students to pursue research-related activities and suggested that medical students especially feel the need to distinguish themselves from others in order to gain a competitive residency spot.[12,46] Research is not only seen as a means to distinguish oneself from others, but in some studies also proven to increase the likelihood of matching success.[47-49] Conducting research with the aim to secure a competitive residency spot is an example of extrinsic motivation for research. Alberson and colleagues describe this as an 'accomplishment related' or 'product-focused' goal where students value the product without valuing the process.[50] Despite the known extrinsic benefits of conducting research, it is intrinsic motivation for research that increases the odds of involvement in research during early phases of medical training. One possible explanation could be that these young medical students are not yet aware of the competitive nature surrounding certain specialties. Another possible explanation could be that embedding a mandatory research course in the first year of medical training, like Leiden University Medical Center does,[35] contributes to stimulating intrinsic motivation for research and process-focused goals among students. A research course with authentic learning tasks in which the relevance of research for clinical practice is made clear could, according to Alberson and colleagues, help to enhance process-focused goals instead of product-focused goals.[50] Next to introducing the relevance of research for clinical practice, this offers students the possibility to become acquainted with research and perform research themselves. If students are able to successfully conduct research, this could contribute to their self-efficacy beliefs. In turn, according to Bandura's self-efficacy theory and our previous study, self-efficacy contributes to students' intrinsic motivation for research.[30,36] Lastly, students acknowledge that research is very time consuming.[12,34,51,52] It could be that students identify reasons to pursue research from an extrinsic perspective, but only decide to commit to such a complex and time consuming activity as a result of intrinsic motivators.

Despite the high levels of both intrinsic and extrinsic motivation for research among students in this study, intrinsic motivation was decisive when it came to getting involved in research. As one of the goals of most medical schools is to deliver some future physician-scientists, this emphasizes the need to keep promoting intrinsic motivation for research among medical students throughout medical training. SDT describes three basic psychological needs to increase intrinsic motivation: the need for autonomy, competence, and relatedness. By providing students with autonomy, promoting feelings of competence, and stimulating relatedness, intrinsic motivation could be enhanced.[31,44] Practically, this could mean that students should be given the opportunity to autonomously conduct research within a supporting research group. Furthermore, our previous studies indicated that perceptions of research, curiosity, need for challenge, and inspiring role models (e.g. parents, teachers, significant others) contribute to intrinsic motivation as well.[36] By promoting positive perceptions of research, for instance by elaborating on the value of research for clinical practice, intrinsic motivation could be enhanced.[46] In line with this, a study by Lopes and colleagues suggested that the ability to make a difference for patients is an important factor in long-term career planning.[53] This underpins the need to show young medical students the valuable role research could play in improving patient care.

Within our study, we established that intrinsic motivation is related to research involvement during medical training. It is plausible to assume that students interested in research during medical training stay engaged in research in the future. Indeed, previous studies have suggested that engagement in research during medical training is related to involvement in research during professional practice. Lopes and colleagues reported that greater research involvement during medical training was associated with the ambition to pursue a clinical academic career.[53] Amgad and colleagues performed a meta-analysis and reported that students who were engaged in research during medical training were over three times as likely to get involved in research during their future careers and six times as likely to pursue an academic career.[46] Brass and colleagues studied the positions of alumni after participating in research during medical training and indicated that around 80% of the graduates were working within academia, of which 82% were still actively conducting research.[28] This supports the assumption that research involvement during medical school is related to long-term research involvement. Therefore, we believe that second-year research involvement as a result of early intrinsic motivation could be seen as the first advancement in cultivating future physician-scientists.

To summarize, our findings suggest that motivation for research could indeed be seen as a key outcome to involve students in research. However, the type of motivation is essential. Therefore, mainly *intrinsic* motivation for research could be posed as a legitimate key outcome in medical education studies. To conclude, intrinsic motivation should be stimulated in students in order to promote research involvement and could indeed be seen as a first step towards success to foster the physician-scientist workforce.

This study comes with some limitations. Firstly, this study is a single-school study, which could impact the generalizability of this study. However, we believe that the LUMC is comparable to other institutes within the Netherlands as our educational programme is structured in a comparable manner according to the Dutch National Blueprint.[37] Secondly, involvement in research was partly operationalized as enrolment in the research-based Honours programme. The research-based Honours programme offers an individualized trajectory during the second and third year of medical training. As the programme is personalized and adjusted to different needs of students, it is possible that students will differ in the type and amount of research conducted during this two-year programme.[22] Information regarding type and amount of research conducted is not yet available and thus not included in this study. Lastly, in line with the SDT, we distinguished two types of motivation for research (intrinsic and extrinsic motivation for research), as both types of motivation are common within the medical context. In a refined version of the SDT, extrinsic motivation is divided within four types, varying in the quantity of external influence and internalization.[31,44,54] The items within our validated scale are mostly related to the external and introjected regulation category, which represent the least internalized forms of extrinsic motivation. In the medical context, securing a competitive residency spot is one of the most mentioned extrinsic incentives, which indeed belongs in the least internalized categories of extrinsic motivation. However, an interesting future research avenue could include the more internalized types (i.e. identified and integrated regulation) of extrinsic motivation as well in order to investigate whether the differences between intrinsic and extrinsic motivation remain. In addition, it would be interesting to investigate whether students continue to be intrinsically motivated throughout the programme. Furthermore, it would be valuable to examine if intrinsic motivation for research is related to long-term involvement in research as well.

Conclusions

Intrinsic motivation for research influences future research involvement among young medical students, also after adjusting for multiple factors. Extrinsic motivation for research does not affect research involvement after adjusting for the same factors and does not contribute on top of intrinsic motivation. Our findings suggest that type of motivation matters and that intrinsic motivation yields the most desirable outcomes. Therefore, we argue that intrinsic motivation should be targeted to stimulate research engagement and could indeed be seen as a first step towards success in cultivating future physician-scientists and fostering the physician-scientist workforce.

Strengths and limitations of this study

- This is the first prospective study among medical undergraduates to investigate if self-reported motivation for research leads to actual research involvement.
- Our study investigates if students act upon their self-reported motivation for research, while other studies mainly pose motivation for research as the key outcome measure.
- Previous research relies mainly on retrospective data or a cross-sectional design from which causality cannot be inferred.
- This study includes nearly all medical students of one single cohort (99.7%).
- Our data was collected within a single institute and generalizability beyond research intensive universities with the same structure as those in the Netherlands needs further study.

References

1. Bell J, Working Group of Academy of Medical S. Resuscitating clinical research in the United Kingdom. *BMJ (Clinical research ed)*. 2003;327(7422):1041-1043.
2. Woolf SH. The Meaning of Translational Research and Why It Matters. *Jama*. 2008;299(2):211-213.
3. Lander B, Hanley GE, Atkinson-Grosjean J. Clinician-scientists in Canada: barriers to career entry and progress. *PloS one*. 2010;5(10).
4. Harding CV, Akabas MH, Andersen OS. History and Outcomes of 50 Years of Physician–Scientist Training in Medical Scientist Training Programs. *Academic Medicine*. 2017;92(10):1390-1398.
5. DeLuca GC, Ovseiko PV, Buchan AM. Personalized medical education: Reappraising clinician-scientist training. *Science translational medicine*. 2016;8(321):321fs322-321fs322.
6. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017;6(6):366–368.
7. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017;65(5):942-948.
8. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
9. Swing SR. The ACGME outcome project: retrospective and prospective. *Medical Teacher*. 2007;29(7):648-654.
10. Clough S, Fenton J, Harris-Joseph H, et al. What impact has the NIHR Academic Clinical Fellowship (ACF) scheme had on clinical academic careers in England over the last 10 years? A retrospective study. *BMJ open*. 2017;7(6):e015722.
11. Yin C, Steadman PE, Apramian T, et al. Training the next generation of Canadian Clinician-Scientists: charting a path to success. *Clinical and investigative medicine*. 2017;40(2):E95-E101.
12. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
13. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
14. Funston G, Piper RJ, Connell C, Foden P, Young AMH, O'Neill P. Medical student perceptions of research and research-orientated careers: An international questionnaire study. *Medical Teacher*. 2016;38(10):1041-1048.
15. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
16. Goldhamer MEJ, Cohen AP, Bates DW, et al. Protecting an Endangered Species: Training Physicians to Conduct Clinical Research. *Academic Medicine*. 2009;84(4):439-445.
17. Yoon S, Koh WP, Ong MEH, Thumboo J. Factors influencing career progress for early stage clinician-scientists in emerging Asian academic medical centres: a qualitative study in Singapore. *BMJ open*. 2018;8(3):e020398.
18. NIH. Physician-scientist Workforce (PSW). Working Group Report. NIH Web site. http://acd.od.nih.gov/reports/PSW_Report ACD_06042014.pdf. Updated June 1, 2014. Accessed February 3, 2020. 2. NIH. Biomedical Research Workforce. 2014.

19. MMC. Medically- and dentally-qualified academic staff: recommendations for training the researchers and educators of the future. Report of the Academic Careers Sub-Committee of Modernising Medical Careers and the UK Clinical Research Collaboration. London: UK: CRC, 2005. http://www.ukcrc.org/wp-content/uploads/2014/03/Medically_and_Dentally-qualified_Academic_Staff_Report.pdf. (accessed 15 April 2019).
20. Reinders JJ, Kropmans TJ, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. *Medical Education*. 2005;39(2):237.
21. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.
22. Ommering BWC, van den Elsen PJ, van der Zee J, Jost CR, Dekker FW. Using an Extracurricular Honors Program to Engage Future Physicians Into Scientific Research in Early Stages of Medical Training. *Medical Science Educator*. 2018;28(2):451-455.
23. Laskowitz DT, Drucker RP, Parsonnet J, Cross PC, Gesundheit N. Engaging students in dedicated research and scholarship during medical school: the long-term experiences at Duke and Stanford. *Academic Medicine*. 2010;85(3):419-428.
24. Wolfson RK, Alberson K, McGinty M, Schwanz K, Dickins K, Arora VM. The Impact of a Scholarly Concentration Program on Student Interest in Career-Long Research: A Longitudinal Study. *Academic Medicine*. 2017;92(8):1196-1203.
25. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching.* Dordrecht: Springer Science + Business Media; 2014.
26. Healey M, Jordan F, Pell B, Short C. The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International*. 2010;47(2):235-246.
27. Graham MJ, Frederick J, Byars-Winston A, Hunter AB, Handelsman J. Increasing Persistence of College Students in STEM. *Science.* 2013;341(6153):1455-1456.
28. Brass LF, Akabas MH, Burnley LD, Engman DM, Wiley CA, Andersen OS. Are MD-PhD programs meeting their goals? An analysis of career choices made by graduates of 24 MD-PhD programs. *Academic Medicine*. 2010;85(4):692-701.
29. Skinnider MA, Twa DD, Squair JW, Rosenblum ND, Lukac CD, Group CMPPI. Predictors of sustained research involvement among MD/PhD programme graduates. *Medical Education*. 2018;52(5):536-545.
30. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.
31. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
32. Burgoyne LN, O'Flynn S, Boylan GB. Undergraduate medical research: the student perspective. *Medical Education Online*. 2010;15(1):5212.
33. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15(1):95.
34. Nel D, Burman RJ, Hoffman R, Randera-Rees S. The attitudes of medical students to research. *South African Medical Journal*. 2014;104(1):32-36.
35. Vereijken MWC, van der Rijst RM, van Driel JH, Dekker FW. Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. *Advances in health sciences education: theory and practice.* 2018;23(2):371-385.

36. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education*. 2018.

37. Ten Cate O. Medical education in the Netherlands. *Medical Teacher.* 2007;29(8):752-757.

38. Deci EL, Eghrari H, Patrick BC, Leone DR. Facilitating internalization: the self-determination theory perspective. *Journal of personality.* 1994;62(1):119-142.

39. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in health psychology: A user's portfolio. Causal and control beliefs.* Windsor, UK: NFER-NELSON; 1995:35-37.

40. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L, Freeman KE. *Manual for the Patterns of Adaptive Learning Scales (PALS).* Ann Arbor: University of Michigan2000.

41. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International.* 2016:1-8.

42. Litman JA. Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences.* 2008;44(7):1585-1595.

43. Vansteenkiste M, Sierens E, Soenens B, Luyckx K, Lens W. Motivational Profiles From a Self-Determination Perspective: The Quality of Motivation Matters. *Journal of Educational Psychology.* 2009;101(3):671-688.

44. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* Guilford Publications; 2017.

45. Ranieri V, Barratt H, Fulop N, Rees G. Factors that influence career progression among postdoctoral clinical academics: a scoping review of the literature. *BMJ open.* 2016;6(10):e013523.

46. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one.* 2015;10(6):e0127470.

47. Rinard JR, Mahabir RC. Successfully matching into surgical specialties: an analysis of national resident matching program data. *Journal of graduate medical education.* 2010;2(3):316-321.

48. Beres A, Baird R, Puligandla PS. Success in the Pediatric Surgery Match: a survey of the 2010 applicant pool. *Journal of pediatric surgery.* 2011;46(5):957-961.

49. Claiborne JR, Crantford JC, Swett KR, David LR. The Plastic Surgery Match Predicting Success and Improving the Process. *Annals of Plastic Surgery.* 2013;70(6):698-703.

50. Alberson K, Arora VM, Zier K, Wolfson RK. Goals of medical students participating in scholarly concentration programmes. *Medical Education.* 2017;51(8):852-860.

51. Mina S, Mostafa S, Albarqawi HT, et al. Perceived influential factors toward participation in undergraduate research activities among medical students at Alfaisal University-College of Medicine: A Saudi Arabian perspective. *Medical Teacher.* 2016;38:S31-S36.

52. Siemens DR, Punnen S, Wong J, Kanji N. A survey on the attitudes towards research in medical school. *BMC Medical Education.* 2010;10.

53. Lopes J, Ranieri V, Lambert T, et al. The clinical academic workforce of the future: a cross-sectional study of factors influencing career decision-making among clinical PhD students at two research-intensive UK universities. *BMJ open.* 2017;7(8):e016823.

54. Ten Cate TJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. *Medical Teacher.* 2011;33(12):961-973.

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Academic success experiences: promoting research motivation and self-efficacy beliefs among medical students

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Abstract

Theory: Medicine is facing a physician-scientist shortage. Medical training could contribute to developing physician-scientists by stimulating student research involvement, as previous studies showed this is related to research involvement in professional practice. Motivation for research and research self-efficacy beliefs are related to student research involvement. Based on Social Cognitive Theory, success experiences in doing research may enhance research motivation and self-efficacy beliefs. However, the role and type of success experiences in promoting research self-efficacy beliefs and motivation especially early in medical training has not yet been investigated. Therefore, we examined if academic success experiences within an undergraduate course in academic and scientific skills increased research motivation and self-efficacy beliefs among medical students. Furthermore, type of success experience was taken into account by looking at the effects of academic success experiences within standard (i.e. exam) versus authentic (i.e. research report and oral presentation) assessments.

Hypothesis: It was hypothesized that academic success experiences increase intrinsic motivation for research and self-efficacy beliefs. Furthermore, we hypothesized that authentic assessments influence intrinsic motivation for research and self-efficacy beliefs to a larger degree than standard assessments, as the authentic assessments mirror real-world practices of researchers.

Method: First-year undergraduate medicine students followed a course in academic and scientific skills in which they conducted research individually. Their academic success experiences were operationalized as their grades on two authentic research assessments (written report and oral presentation) and one less authentic assessment (written exam). We surveyed students before the course when entering medical school (i.e. baseline measure) and one year after the course in their second year (i.e. post-measure). Both the baseline and post-measure surveys measured intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy beliefs. Linear regression analyses were used to examine the relationship between academic success experiences and intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy beliefs on the post-measure. We adjusted for prior research motivation and self-efficacy beliefs at baseline. Therefore, this adjusted effect can be interpreted as an increase or decrease in motivation. In addition, we adjusted for age, gender, and grade point average (GPA) of the first four months as these variables were seen as possible confounders.

Results: 243 out of 275 students participated (88.4%). Academic success experiences in writing and presenting research were related to a significant increase in intrinsic motivation for research. After adjusting for prior GPA, only the effect of presenting remained. Experiencing success in presenting enhanced research self-efficacy beliefs, also after adjusting for prior GPA. Higher grades on the exam did not affect intrinsic motivation for research or research self-efficacy significantly. Also, none of the success experiences influenced extrinsic motivation for research.

Conclusions: Academic success experiences on authentic research tasks, especially presenting research, may be a good way to enhance intrinsic motivation for research and research self-efficacy beliefs. In turn, research motivation and self-efficacy beliefs promote research involvement, which is a first step in the physician-scientist pipeline. Furthermore, this study established the applicability of the Social Cognitive Theory in a research context within the medical domain.

Introduction

The medical field is currently facing a global physician-scientist shortage. A decrease in interest among medical graduates to pursue a continued research career combined with an ageing physician-scientist workforce is noted in the United States, Canada, and Europe.[1-7] Consequently, serious concerns have been raised regarding the future of academic medicine.

Physician-scientists devote a substantial amount of their professional time to both clinical care and research.[8] Consequently, physician-scientists have the unique ability to identify relevant clinical problems which can be translated into adequate research questions and designs. At the same time, these physician-scientists take a leading role in the translation and implementation of research outcomes into clinical practice.[9-14] Therefore, physician-scientists are believed to be key in bridging the gap between science and clinical practice, and thus for making advancements within the medical domain.

The question how to train and retain the physician-scientist workforce is a much-discussed topic within the last decades.[1,8,13,15-17] One of the mentioned possible solutions is to engage medical students in research during early phases of medical training.[1,4,18-20] Furthermore, in general, engaging medical students in research is needed to deliver graduates with an academic mindset that are able to use research in clinical decision making, thereby practicing evidence-informed medicine. The importance of developing academic skills has been underlined by many medical educational frameworks and accrediting bodies.[15,21,22] To this end, many research-related courses within or on top of the curriculum are emerging within medical school.[18,23,24] These research-related courses and programmes could contribute to students' ability to use research in future daily clinical practice. Furthermore these research-related courses and programmes may help to enhance motivation to engage in research and in turn, hopefully, to the choice to pursue a research oriented career.[1,6,25]

Motivation has been researched from various theoretical perspectives. Self-Determination Theory (SDT) describes two types of motivation: intrinsic motivation (i.e. involvement in an activity out of pure interest or enjoyment) and extrinsic motivation (i.e. involvement in an activity because it is rewarding, with the rewards being external in nature). Intrinsic motivation is believed to be of better quality as it promotes better academic performances, deep learning, and general wellbeing among individuals. Thus, SDT advocates that intrinsic motivation should be stimulated to reach these desired outcomes.[26,27] However, important to mention is that regarding extrinsic motivation a process of internalization could take place, referring to "taking in a behavioural regulation and the value that underlies it" (p.333). Selective application of external rewards can lead to increased feelings of autonomy and ultimately intrinsic motivation.[28] According to Bandura's Social Cognitive Theory (SCT), mastery of an activity and experiencing success within an activity are related to higher self-efficacy beliefs and motivation. SCT focuses on task or domain specific self-efficacy, which can be defined as the belief someone has in being able to accomplish a certain task. This means that successfully performing a task can foster positive self-beliefs about the ability to accomplish that task. This in turn can motivate people to perform the task more frequently. Thus, success experiences lead to positive self-efficacy beliefs, which in turn can reinforce future behavior.[29]

Within the context of undergraduate research, this could mean that a success experience within a research-related course may contribute to medical students' research self-efficacy beliefs and intrinsic motivation for research. If this is indeed the case, evidence-based strategies could be implemented to promote research-based success experiences among undergraduate students. As motivation for research is related to research involvement during medical school,[30] which in turn is related to research involvement in professional practice,[31] first steps to develop graduates with an academic mindset, or even future physician-scientists, could be made early on in medical training. However, the role and type of success experiences in promoting research self-efficacy beliefs and intrinsic motivation for research especially early in medical training has not yet been investigated. Some previous studies did focus on how medical students can be motivated for research, however, these studies mainly focused on later clinical phases and did not examine the role of academic success experiences.[1,32,33]Additionally, studies directly examining research success while also studying the impact of different types of success experiences are absent. Investigating the role and type of direct research-related success experiences could offer important implications for designing and implementing interventions to promote research engagement.

Therefore, the aim of this study is to examine if an academic success experience within an obligatory research course relates to an increase in motivation for research and research self-efficacy beliefs. Furthermore, this study investigates if the possible effect of a success experience differs when the type of assessment is taken into account, looking at standard (i.e. written exam) versus more authentic (i.e. written report and oral presentation) assessments. We hypothesized that authentic, domain specific assessments such as a written report and oral presentation influence intrinsic motivation for research and research self-efficacy beliefs to a larger degree than standard assessments such as an exam, as the authentic assessments mirror real-world practices of researchers and aligns with SCT's task or domain specificity.

Methods

Design and participants

This prospective cohort study is part of a larger longitudinal study that is currently running, in which one cohort of medical undergraduates is followed through medical school. All students who started their first year of medical training in 2016 at Leiden University Medical Center (LUMC) were asked to participate in this study and invited to fill in a questionnaire (Appendix C) each year. The first request to fill in a questionnaire was at the start of medical school in 2016. Students were asked to fill in the same questionnaire in all consecutive years of medical training. Furthermore, grades of every participating student before the research-related course were obtained. In the present study, all students who participated in both the first and second survey were included. Thus, participants were surveyed before the course when entering medical school (i.e. baseline measure) and one year after the course in their second year of medical training (i.e. post-measure) to measure intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy beliefs on both time points.

Context

The LUMC is one of eight medical faculties in the Netherlands providing students with medical training. All faculties are comparable in the structure of their educational programme with six years of undergraduate medical study, divided in a three-year programme leading to a Bachelor's degree and a subsequent three-year programme leading to a Master's degree in Medicine. All eight faculties developed and implemented their educational programme in line with the Dutch National Blueprint for Medical Education, which is based on the Canadian Medical Education Directives for Specialists (CanMEDS) and the U.S. Accreditation Council for Graduate Medical Education (ACGME) Core Competencies.[21,22,34]

At the start of the second semester, the LUMC offers first-year students a mandatory course on academic and scientific skills, in which all students individually conduct a short two-week research project by: (1) gathering and processing patient data, (2) formulating their own research question, (3) analysing data, (4) writing a research report, and (5) presenting their research to teachers and other students.[25,35] To scaffold this process, students follow three in-depth workgroup sessions led by the same teacher. Students are assessed in a standard way with an exam (focusing on statistical and epidemiological knowledge predominantly), representing 60% of the eventual grade for the course. Furthermore, students are also assessed in a more authentic way by writing a research report and orally presenting their research, both accounting for 20% of the eventual course grade. The research report and presentation are graded with a rubric by their teacher of the workgroup sessions. The teachers of the workgroup sessions are PhD candidates or physician-scientists. Before the start of the workgroup sessions, teachers attend a briefing to inform them on the content of the sessions and grading students' written report and oral presentation.

Materials and definitions

Motivation for research and research self-efficacy were measured with a questionnaire that was based on existing and validated scales.[30] Motivation for research was measured with two scales: intrinsic motivation for research (IMR), which was based on five items of the Interest/Enjoyment Scale of the SDT questionnaires, and extrinsic motivation for research (EMR), which was based on four items of the Value/Usefulness Scale of the SDT questionnaires.[26,36] Since the SDT-scales focus on an activity in general, we adjusted these scales with a focus on research activities. For instance, one item of the Interest/Enjoyment scale of the SDT was 'this activity is fun to do', which we have adjusted into 'doing research is fun'. Furthermore, the Perceived/Usefulness scale consists of items like 'I think that doing this activity is useful for ….' – we filled in the blanks and made one of our items: 'I think doing research is useful for my resume'. Also, we made sure to take the medical education setting into account. For instance, as can be found in previous studies, one of the most important extrinsic motivators is securing a competitive residency spot. As the SDT questionnaires did not originate within the medical education setting, we critically evaluated the existing items and adjusted them when deemed necessary. One of the items in the original scale is 'I think this activity could help me to…', which we adjusted into 'I think doing research improves my chances for my preferred residency spot'. As a result, the IMR-scale measured the degree of wanting to be or being involved in conducting research out of interest or enjoyment and the EMR-scale measured the degree of wanting to or being involved in conducting research because it is rewarding, for example to secure a competitive residency spot. Research self-efficacy was defined as beliefs students have regarding their ability to conduct research. The research self-efficacy scale, existing out of three items, was self-developed and inspired by the Dutch General Self-Efficacy Scale and the Academic Efficacy Scale.[37,38] For example, the Academic Efficacy Scale contains, among others, the item 'I am certain I can master the skills taught in class this year', which inspired one of our items in the research self-efficacy scale, namely 'I feel I master the skills to do research'. Students were asked to score the scale-items on a 7-point Likert scale ranging from *1 – 'totally disagree'* to *7 – 'totally agree'*.

Academic success experiences were operationalized as the grades students obtained on the mandatory course on academic and scientific skills in the first year of medical training, in which students individually conducted clinical research within an authentic setting. Students received a grade on their exam, a grade on their written report including delayed written feedback after two weeks, and a grade on their oral presentation including direct oral feedback. Within this study, grades were seen as a proxy for academic success experiences and higher grades were believed to represent more positive academic success experiences among students.

Procedure

After adjusting the existing motivational scales and developing the research self-efficacy scale, the questionnaire was translated from English to Dutch by using the forward and backward translation procedure. The questionnaire was pretested on medical students from a different cohort, who were at that time second-year medical students, leading to a few minor adjustments to two items. All first-year medical students of the targeted cohort were approached in the first semester of the first year of medical training in 2016. They were asked to complete the questionnaire during a scheduled workgroup session (T1 baseline measure – November 2016). In the second semester of the first year, students followed the obligatory course in which they individually conducted clinical research (January 2017). The students were approached again with the same questionnaire in the first semester of their second year of medical training (T2 post-measure – January 2018).

Both at T1 and T2 students were informed that the study investigated scientific training during medical school. It was communicated to students that participation was completely voluntary and that all data would be processed anonymously. Furthermore, consent was asked to link data of both questionnaires and to gather data regarding the obtained grades of participating students. Students followed three courses which were not related to research (e.g. cell biology) before following the course on academic and scientific skills (January 2017). The grades of these prior courses were used to operationalize students' grade point average (GPA) of the first four months. The study was approved by the ethical review board of the Netherlands Association of Medical Education: reference number 952.

Analysis

We used descriptive statistics to report age and gender of the included students. To estimate the reliability of the scales, we calculated Cronbach's alpha. We calculated mean scores for intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy. We applied mean substitution for missing values if students answered more than 70% of the items on a scale (applied in 1.7% of the students). Furthermore, we calculated students' GPA of the first four months by calculating a mean score of the grades obtained in the three courses prior to the scientific course in the first year. If students missed one of the three grades, we applied mean substitution for missing values (applied in 3.7% of the students). To assess if an academic success experience within scientific education leads to an increase in motivation for research and research self-efficacy, we performed linear regression analysis with success experience (i.e. grade for the exam, presentation or report, analysed in separate linear regressions) as the independent variable and motivation or research self-efficacy in the second year (i.e. T2) as the dependent variable. We adjusted for the scores students had on motivation for research and research self-efficacy at the start of medical training (i.e. T1 baseline scores), so this adjusted effect can be interpreted as an increase or decrease in motivation. Within this relationship, we wanted to adjust for multiple possible confounders, one of which is prior GPA. To avoid interfering within the causal path, only GPA before the start of the course in which academic success experiences were examined could be included, which is the GPA of the first four months of medical training. Furthermore, we adjusted for age and gender. We present 95% confidence intervals and consider $p < .05$ as statistically significant. We analysed all data using IBM SPSS Statistics version 23.

Results

A total of 243 out of 275 students participated in both the first (T1) and second (T2) survey and were thus included in this study (88.4%). This study consisted of 57 male (23.5%) and 186 female (76.5%) participants. Students had a mean age of 19.68 years (*SD* = 1.11). Mean scores of students on intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy beliefs on both timepoints as well as the Cronbach's alpha of the scales can be found in Table 1.

Table 1. Mean scores of students on baseline measure (T1) and post-measure (T2), reliability, and sample items of the scales [a]

	T1 Mean (SD)	T1 Cronbach's α	T2 Mean (SD)	T2 Cronbach's α	Sample item
Intrinsic Motivation *(5 items)*	5.52 (.69)	.76	5.29 (.81)	.80	Doing research is fun
Extrinsic Motivation *(4 items)*	5.65 (.78)	.76	5.61 (.89)	.82	I think doing research improves my chances for my preferred residency spot
Research self-efficacy *(3 items)*	4.86 (.93)	.87	4.75 (.97)	.86	I feel I am competent enough to do research

[a] n = 243, Based on a 7-point Likert scale (1 – 'totally disagree' to 7 – 'totally agree')

Intrinsic motivation for research

Linear regression analyses showed that an academic success experience on the exam was not related to higher levels of intrinsic motivation for research (β =.059, 95% CI = -.025 - .143, p =.170), while an academic success experience on the oral presentation (β =.115, 95% CI = .017 - .214, p =.022) and research report (β =.114, 95% CI = .017 - .211, p =.022) were significantly and positively related to an increase in intrinsic motivation for research. However, after adjusting for the T1 baseline scores, age, gender, and GPA of the first four months, only an academic success experience on the oral presentation remained significant (β =.099, 95% CI = .001 - .197, p =.049). An overview of the cumulative regression model of intrinsic motivation can be found in Table 2.

Table 2. Cumulative linear regression model of the effect of a success experience in an exam, oral presentation or written research report within an obligatory research course during the first year of medical training on levels of intrinsic motivation during the second year of medical training

	Intrinsic Motivation (T2) β (95%CI) *p*, R^2				
	Crude	Adjusted for T1 baseline scores	Idem + age	Idem + gender	Idem + GPA 4 months
Exam	.059 (-.025 - .143) *.170, .008*	.041 (-.037 - .119) *.300, .156*	.044 (-.034 - .123) *.264, .161*	.043 (-.036 - .121) *.283, .164*	.002 (-.088 - .092) *.966, .177*
Presentation	.115 (.017 - .214) *.022, .024*	.128 (.037 - .218) *.006, .190*	.128 (.038 - .218) *.006, .193*	.123 (.032 - .214) *.008, .195*	.099 (.001 - .197) *.049, .202*
Report	.114 (.017 - .211) *.022, .024*	.090 (.000 - .180) *.050, .175*	.090 (.001 - .180) *.048, .179*	.085 (-.006 - .176) *.066, .182*	.058 (-.037 - .154) *.339, .192*

[a] Idem means that with every step in the regression model, one confounder is added on top of the variables specified in the previous line

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Extrinsic motivation for research

Academic success experiences were not significantly related to an increase in extrinsic motivation for research (Table 3).

Table 3. Cumulative linear regression model of the effect of a success experience in an exam, oral presentation or written research report within an obligatory research course during the first year of medical training on levels of extrinsic motivation during the second year of medical training

	Extrinsic Motivation (T2) β (95%CI) *p*, R^2				
	Crude	Adjusted for T1 baseline scores	Idem + age	Idem + gender	Idem + GPA 4 months
Exam	.020 (-.075 - .115) *.680, .001*	-.010 (-.095 - .075) *.822, .216*	-.012 (-.097 - .073) *.776, .220*	-.009 (-.094 - .076) *.827, .229*	-.043 (-.141 - .054) *.384, .236*
Presentation	-.029 (-.142 - .083) *.606, .001*	-.029 (-.128 - .071) *.570, .221*	-.029 (-.129 - .070) *.559, .225*	-.020 (-.120 - .081) *.701, .232*	-.046 (-.153 - .061) *.399, .238*
Report	.011 (-.099 - .122) *.838, .000*	.003 (-.094 - .101) *.944, .220*	.003 (-.095 - .100) *.958, .224*	.012 (-.086 - .111) *.807, .231*	-.007 (-.111 - .097) *.895, .236*

[a] Idem means that with every step in the regression model, one confounder is added on top of the variables specified in the previous line

Research self-efficacy beliefs

Linear regression analyses showed that academic success experiences on the exam and research report were not related to an increase in research self-efficacy (*β* =.043, 95% CI = -.060 - .147, *p* =.408 and *β* =.057 , 95% CI = -.061 - .175, *p* =.343 respectively), also after correcting for the T1 baseline scores, age, gender, and GPA of the first four months (*β* =.059 , 95% CI = -.048 - .166, *p* =.276 and *β* =.063, 95% CI = -.050 - .176, *p* =.270 respectively). Academic success experience in orally presenting research was not significantly related to research self-efficacy on its own (*β* =.099, 95% CI = -.020 - .218, *p* =.104). However, after adjusting for the T1 baseline scores, age, gender, and GPA of the first four months, an academic success experience on the oral presentation was significantly related to an increase in research self-efficacy (*β* =.122, 95% CI = .006 - .237, *p* =.039). An overview of the cumulative regression model of research self-efficacy is presented in Table 4.

Table 4. Cumulative linear regression model of the effect of a success experience in an exam, oral presentation or written research report within an obligatory research course during the first year of medical training on levels of research self-efficacy during the second year of medical training

	Research self-efficacy (T2) β (95%CI) *p*, R^2				
	Crude	Adjusted for T1 baseline scores	Idem + age	Idem + gender	Idem + GPA 4 months
Exam	.043 (-.060 - .147) *.408, .003*	.056 (-.037 - .148) *.235, .206*	.063 (-.029 - .155) *.180, .222*	.064 (-.028 - .156) *.170, .224*	.059 (-.048 - .166) *.276, .224*
Presentation	.099 (-.020 - .218) *.104, .012*	.113 (.006 - .220) *.035, .209*	.114 (.008 - .220) *.035, .226*	.121 (.014 - .228) *.027, .229*	.122 (.006 - .237) *.039, .229*
Report	.057 (-.061 - .175) *.343, .004*	.063 (-.043 - .169) *.244, .198*	.065 (-.041 - .170) *.228, .215*	.070 (-.036 - .176) *.195, .218*	.063 (-.050 - .176) *.270, .218*

[a] Idem means that with every step in the regression model, one confounder is added on top of the variables specified in the previous line

Discussion

In line with our hypotheses, our results suggest that academic success experiences in writing a research report and orally presenting research are related to an increase in intrinsic motivation for research among undergraduate students. However, after adjusting for students' GPA of the first four months, only the effect of a success experience in orally presenting research remained. Furthermore, our results show that after adjusting for the T1 baseline scores, age, gender, and GPA of the first four months, a success experience in orally presenting research contributes to increasing research self-efficacy beliefs in the second year of medical school. A higher grade on the exam does not affect motivation for research or research self-efficacy and none of the measured success experiences influence higher levels of extrinsic motivation for research.

A higher grade on the exam had no influence on motivation for research or research self-efficacy beliefs among students. This could be explained by the fact that an exam is not part of the process of conducting research and mainly focuses on knowledge instrumental to conducting research. Thus, an exam is a less authentic way to assess students' research performances. Success experiences within more authentic assessments like a written report or oral presentation, however, seem to affect intrinsic research motivation and research self-efficacy. Although overall average intrinsic motivation for research and research self-efficacy beliefs did not noticeably change from baseline measure (T1) to post-measure (T2), differential outcomes, i.e. increased or decreased motivation and self-efficacy, resulting from differing levels of academic success experiences may account for this apparent lack of change.

An academic success experience in writing a research report, on its own, influenced students' intrinsic motivation for research, but did not seem to affect their research self-efficacy beliefs. A possible explanation could be that students enjoy writing a research report, but also find this difficult. Indeed, a previous qualitative study showed that students perceive writing as a fun, but difficult part of conducting research.[39] Subsequently, it could be that writing a research report does not contribute to students' feelings of competence in conducting research. Furthermore, the possibility for dialogue is crucial for the uptake of feedback among students.[40] Within the course, students received written feedback on their report after about two weeks, without engaging in a feedback-dialogue with teachers or peers. This could be a barrier to student uptake and understanding of feedback, which may impact students' self-perceived learning outcomes. In turn, this could explain that the grade and feedback on the research report did not contribute to an increase in research self-efficacy beliefs.

After adjusting for student GPA of the first four months, the crude effect of success experiences in writing a research report on intrinsic motivation disappeared. GPA of the first four months could well be a confounder in the relation between success experiences in writing a research report and intrinsic motivation for research, as it may influence both the grade on the written report as intrinsic motivation for research. This would imply that 'excellent' students perform better, displaying both better academic performance as well as higher levels of motivation. An explanation could be that high grades at the start of medical training contribute to positive general and academic self-efficacy beliefs, which in turn may be related to further academic performance and motivation.[29,33] Associations between GPA and research related parameters are not uncommon, for instance a study by Hren and colleagues showed an association between higher GPA and attitudes towards research.[41]

Contrary to the writing success experiences, success experiences in orally presenting research were positively related to both intrinsic motivation and research self-efficacy, also after adjusting for GPA of the first four months. Why would successfully presenting research enhance both intrinsic motivation and research self-efficacy among undergraduate students? According to Merrill, learning is especially promoted when students have the opportunity to discuss or defend new knowledge.[42] Orally presenting research suits this goal and contributes to feelings of ownership. Presenting research outcomes is a fundamental part of conducting research, which is also recognized by students.[43] Nonetheless, students in this course perceived presenting as a challenging and exciting task, for which they were quite nervous. This results in great relief when they conclude their presentation and receive direct feedback on their performance. This immediately provides them with some sense of how they performed, which is very important and could contribute to their enhanced research self-efficacy beliefs and researcher identity.[31,43] Furthermore, presenting your research in front of a critical audience and receiving feedback allows students to observe their own progress which is very motivating as well.[42] Where the feedback on the report usually lacks opportunities for interaction, giving an oral presentation is extremely suited for feedback dialogue. This dialogue not only promotes student uptake of feedback, but it encourages elaboration and further thinking on research-related content among students as well.[40,43] This is in line with the Social Cognitive Career Theory (SCCT), which to a large extent builds on SCT and proposes that social interactions are important for strengthening self-efficacy beliefs. According to SCCT, verbal persuasive communications (i.e. verbal encouragement) play a crucial role in enhancing self-efficacy beliefs and forming positive outcome expectations.[44] Our finding that mainly presenting one's research contributes to enhanced research self-efficacy beliefs and intrinsic motivation for research could thus be clarified through this perspective as well, as verbal communication and encouragement is very common during or after an oral presentation.

Viewing our results through the lens of SCCT also provides some important implications for cultivating research self-efficacy, and in turn intrinsic motivation for research, among students from minority groups. SCCT states that background characteristics (i.e. race or sex) both influence and interact with the type of learning experiences one is exposed to. In shaping how, for instance, students see themselves, these background characteristics play an important role, as they elicit responses from the environment.[44] Among other things, this could mean that research self-efficacy beliefs and intrinsic motivation for research could decrease if ethnic minority groups receive implicit signals of disapproval during their oral presentation. However, as the population within our study is quite homogeneous, further research is needed to examine this perspective.

Lastly, none of the success experiences affected extrinsic motivation for research. Perhaps these young medical students did not connect success experiences within a first-year research course with the possible rewarding character of conducting research for future career prospects. This is in line with findings by Rosenkranz and colleagues that mainly students in the clinical years of medical training agreed that conducting research is advantageous for their medical career.[32]

To summarize, in line with the Social Cognitive Theory, an academic success experience within an obligatory course does seem to relate to the development of higher levels of intrinsic motivation for research and research self-efficacy among undergraduate students. However, the type of assessment should be taken into account as the effect of a success experience is only present when using authentic assessments, like writing a research report or giving an oral presentation. This underpins the importance of authentic assessment methods, strongly related to aim of and learned content within the course. Type and timing of feedback should be taken into account as well, as experiencing success in orally presenting research with direct feedback dialogue seems to have the greatest influence on both intrinsic motivation and research self-efficacy beliefs among students.

Our results provide some implications for practice. Many medical schools offer research-related courses to medical students, though in many different forms (e.g.

both obligatory and voluntarily).[1,31] If the pre-eminent goal is to deliver graduates with an academic mindset that are, for instance, able to practice evidence-informed decision making and/or to cultivate future physician-scientists, it seems valuable to promote academic success experiences during undergraduate research courses and to assess students' research-related performance in an authentic manner. Our findings suggest that particularly orally presenting and justifying own research is a good method and assessment format to both monitor students' performance as well as to increase intrinsic motivation for research and research self-efficacy beliefs early in medical school. In turn, this could contribute to students' engagement in research later in medical school and future professional practice.[1,30,31] In a wider perspective, our results imply that choosing the assessment type in such a way that it is directly connected to a success experience is of great value within education to increase student motivation and self-efficacy beliefs. To conclude, our study also contributes to theory building as it showed the applicability of the Social Cognitive Theory in a research context within the medical domain with real-world data.

Limitations, strengths and future research

Firstly, our research was conducted within one institute. Furthermore, our cohort consisted of a homogeneous and largely female population with participants of young age. This could impact the generalizability of our findings. However, the medical curriculum of our institute, the male/female distribution, and mean age is comparable to other medical curricula in the Netherlands. All the curricula are based on the same framework (Dutch National Blueprint for Medical Education). Moreover, this framework is aligned with the CanMEDS and ACGME Core Competencies. In addition, many medical schools provide students with research experiences during medical training.[1,45] Although the way medical schools do this may depend on the national (i.e. school system) and local (i.e. medical school) context, we do believe that our findings are generalizable in the sense that research skills are generic skills that can be trained throughout various stages of medical school. Finally, we used oral presentations and research reports as research-authentic proxies for success experience. These forms of assessment may very well be used in other educational contexts as well.

Secondly, we did not ask students about their success experiences directly. Instead of relying on self-reports, we relied on student grades as a proxy for an academic success experience. This can be seen as an objective, yet indirect measure for an academic success experience. Additional research could focus on how students perceive grades as success experiences and how this varies among students. Nonetheless, we do believe that a higher grade always reflects a better feeling among students, which is fostered by including grades as a continuous variable in our analysis. Moreover, high grades can be seen as mastery experiences as stated by the Social Cognitive Theory.[29]

Thirdly, as this was an observational and not a randomized controlled study, it could be that there are some unmeasured confounders in the relation between an academic success experience and research motivation or self-efficacy beliefs. However, building on theory and previous studies, we do believe that we included the most important confounders. Furthermore, we adjusted for a sound baseline measurement of research motivation and self-efficacy beliefs as measured at the start of medical training, two months before the research-related course.

For future research it would be interesting to qualitatively explore students' perceptions of success experiences within a research-related course and how these perceptions influence their intentions to do research in their future career. Furthermore, it would be valuable to monitor how motivation for research and self-efficacy beliefs develop during medical training and how a series of subsequent, research-related courses (perhaps both obligatory and voluntarily) with increasing levels of difficulty affect motivation, self-efficacy and the development of a researcher identity among future physicians.

Conclusion

In line with the Social Cognitive Theory, we verified our hypothesis that academic success experiences within a research course are related to increased intrinsic motivation for research and research self-efficacy beliefs among undergraduate medical students. However, type of assessment seems to play an important role as the effect is only present when using authentic assessment methods, in particular oral presentations of the conducted research. Therefore, we argue that orally presenting research during a research course is a good way to both assess students' performance as well as to stimulate intrinsic motivation for research and research self-efficacy beliefs in early phases of medical training. Subsequently, this may stimulate student engagement in research during medical training and in future professional practice, and provide possibilities to counteract the decline in the physicians-scientist workforce.

References

1. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
2. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
3. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
4. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017;65(5):942-948.
5. Yin C, Steadman PE, Apramian T, et al. Training the next generation of Canadian Clinician-Scientists: charting a path to success. *Clinical and investigative medicine*. 2017;40(2):E95-E101.
6. Stone C, Dogbey GY, Klenzak S, Van Fossen K, Tan B, Brannan GD. Contemporary global perspectives of medical students on research during undergraduate medical education: a systematic literature review. *Medical Education Online*. 2018;23(1):1537430.
7. NIH. Physician-scientist Workforce (PSW). Working Group Report. NIH Web site. http://acd.od.nih.gov/reports/PSW_Report ACD_06042014.pdf. Updated June 1, 2014. Accessed February 3, 2020. 2. NIH. Biomedical Research Workforce. 2014.
8. Sklar DP. We Must Not Let Clinician-Scientists Become an Endangered Species. *Academic Medicine*. 2017;92(10):1359-1361.
9. Abu-Zaid A. Research skills: the neglected competency in tomorrow's 21st-century doctors. *Perspectives on Medical Education*. 2014;3:63-65.
10. Woolf SH. The meaning of translational research and why it matters. *Jama*. 2008;299(2):211-213.
11. Dekker FW. Achieving research competences through medical education. *Perspectives on Medical Education*. 2013;2(4):178-180.
12. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017;6(6):366–368.
13. DeLuca GC, Ovseiko PV, Buchan AM. Personalized medical education: Reappraising clinician-scientist training. *Science translational medicine*. 2016;8(321):321fs322-321fs322.
14. Butler D. Translational research: crossing the valley of death. *Nature*. 2008;453(7197):840-842.
15. Wyngaarden JB. The clinical investigator as an endangered species. *The New England journal of medicine*. 1979;301(23):1254-1259.
16. Rosenberg L. Physician-scientists--endangered and essential. *Science*. 1999;283(5400):331-332.
17. Skinnider MA, Twa DD, Squair JW, Rosenblum ND, Lukac CD, Group CMPPI. Predictors of sustained research involvement among MD/PhD programme graduates. *Medical Education*. 2018;52(5):536-545.
18. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online*. 2013;18.
19. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
20. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.

21. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
22. Swing SR. The ACGME outcome project: retrospective and prospective. *Medical Teacher.* 2007;29(7):648-654.
23. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
24. Scager K, Akkerman SF, Pilot A, Wubbels T. Challenging high-ability students. *Studies in Higher Education*. 2014;39(4):659-679.
25. Vereijken MWC, van der Rijst RM, van Driel JH, Dekker FW. Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. *Advances in health sciences education: theory and practice.* 2018;23(2):371-385.
26. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
27. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications; 2017.
28. Gagne M, Deci EL. Self-determination theory and work motivation. *Journal of Organizational Behavior.* 2005;26(4):331-362.
29. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.
30. Ommering BWC, van Blankenstein FM, Wijnen-Meijer M, van Diepen M, Dekker FW. Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. *BMJ open.* 2019;9(7):e028034.
31. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one.* 2015;10(6):e0127470.
32. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15(1):95.
33. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education*. 2018;7:248-255.
34. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009.* Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
35. Ommering BWC, van Diepen M, van Blankenstein FM, de Jong PGM, Dekker FW. Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students. *Medical Teacher.* 2019.
36. Deci EL, Eghrari H, Patrick BC, Leone DR. Facilitating internalization: the self-determination theory perspective. *Journal of personality.* 1994;62(1):119-142.
37. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in health psychology: A user's portfolio. Causal and control beliefs.* Windsor, UK: NFER-NELSON; 1995:35-37.
38. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L, Freeman KE. *Manual for the Patterns of Adaptive Learning Scales (PALS).* Ann Arbor: University of Michigan2000.

39. Ommering BWC, Wijnen-Meijer M, Dolmans DHJM, Dekker FW, van Blankenstein FM. Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. *BMC Medical Education*. 2020;20(1):204.

40. Carless D, Boud D. The development of student feedback literacy: enabling uptake of feedback. *Assessment & Evaluation in Higher Education*. 2018;43(8):1315-1325.

41. Hren D, Lukic IK, Marusic A, et al. Teaching research methodology in medical schools: students' attitudes towards and knowledge about science. *Med Educ*. 2004;38(1):81-86.

42. Merrill MD. First principles of instruction. *Educational Technology Research and Development*. 2002;50(3):43-59.

43. Walkington H, Hill J, Kneale PE. Reciprocal elucidation: a student-led pedagogy in multidisciplinary undergraduate research conferences. *Higher Education Research & Development*. 2017;36(2):416-429.

44. Bakken LL, Byars-Winston A, Wang MF. Viewing clinical research career development through the lens of social cognitive career theory. *Advances in Health Scienses Education: theory and practice*.. 2006;11(1):91-110.

45. Burk-Rafel J, Mullan PB, Wagenschutz H, Pulst-Korenberg A, Skye E, Davis MM. Scholarly Concentration Program Development: A Generalizable, Data-Driven Approach. *Academic Medicine*. 2016;91(11 Association of American Medical Colleges Learn Serve Lead: Proceedings of the 55th Annual Research in Medical Education Sessions):S16-S23.

6

Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation

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Abstract

Introduction: Engagement of clinicians in research is important for the integration of science and clinical practice. However, at this moment, there is a shortage of physician-scientists. Success experiences can stimulate student interest in a research career. Conducting actual research leading to publication is a potential method to gain a success experience. This study assessed whether publication as a medical student is associated with publication after graduation. We determined whether medical students in the Netherlands who are involved in research, as measured by publication in international journals before graduation, 1) are more likely to publish, 2) publish a greater number of papers, and 3) have higher citation impact scores after graduation.

Methods: We matched 2005-2008 MD graduates (with rare names, $n = 4145$ in total) from all eight Dutch university medical centres to their publications indexed in the Web of Science and published between 6 years before and 6 years after graduation. For sensitivity analysis we performed both automatic assignment on the whole group and manual assignment on a 10% random sample.

Results: Students who had published before graduation: 1) were 1.9 times as likely to publish, 2) published more papers, and 3) had a slightly higher citation impact after graduation.

Discussion: Medical students who conducted research leading to a publication before graduation were more likely to be scientifically active after graduation. While this is not a causal relationship *per se*, these results cautiously suggest that successful early involvement in research could influence the long-term scientific activity of clinicians.

What this paper adds

Scientific education is an important element in all medical curricula in the Netherlands, as it trains medical students to use research in their clinical practice and prepares a subgroup to conduct research themselves. Previous studies have shown that quite a few medical students publish a paper before graduation. However, the long-term impact of early publication on the later scientific publication career was not known. Using validated bibliometric methods, we found that publication before graduation is associated with an increased likelihood of publication after graduation, a greater number of publications after graduation, and a slightly higher citation impact after graduation.

Introduction

What's learnt in the cradle lasts to the tomb: a saying that applies to activities like riding a bicycle. But does it also apply to the involvement of clinicians in science? All clinicians should at least be able to use research in their clinical practice, a competency required by the Netherlands Federation of University Medical Centres, the U.S. Accreditation Council for Graduate Medical Education (ACGME) and the Canadian Medical Education Direction for Specialists (CanMEDS), among others.[1-3] In addition, we need clinicians who conduct research themselves: physician-scientists. However, there is a shortage of physician-scientists, which is visible in multiple places in the world, for example in the United States, Canada, and Europe.[4-8]

This shortage is thought to lead to undesirable effects. For example, it has been argued that clinical practice and science have become too disengaged - into patient care on the one hand and basic research on the other.[9] As a result, medical research might lose clinical relevance, while clinical problems might remain unanswered. The question is how to stimulate clinicians to become and stay involved in research. An answer may lie in scientific education during medical training.[10]

Formal scientific education can take various shapes and forms.[11] These may be categorized according to student involvement: students as audience or participants. In the forms where students are the audience, learning is quite passive. However, in the forms where students are participants, students learn actively about research, which has been asserted to be a much more effective form of scientific education.[12]

The ultimate form of active learning in scientific education, it can be argued, is participation of students in the scientific process. Often, this takes the form of research projects, which usually take place in the graduate phase, but may also take place in the undergraduate phase.[13-15] Undergraduate students are motivated to do research already early in their studies. This provides an opportunity to engage them in research early on in medical training.[10] The question is what the long-term outcomes are of such early engagement in research.[4]

Here, we study whether publication during medical training, capped by authorship of one or more scientific publications, is associated with the post-graduation scientific activity of medical graduates. Are medical students who experience success in the sense that they successfully go through both the research process and the scientific publication process more likely to stay involved in research and keep publishing after graduation? There have been other studies that predict research engagement after medical training, but these often focus on either scholarly concentration or MD/PhD programmes, not on the larger group of MD graduates.[16-18] In addition, many of these do not directly evaluate scientific publication as an outcome variable but rather the intention to be involved in research.[18-20]

We use bibliometric methods to study the relationship between pre-graduation and post-graduation publication. Bibliometric methods are especially suitable to study this relationship, as they can be used to track the scientific performance of individuals, reinforcing its strength by grouping the scores of individuals to larger sets of publications, with more robust bibliometric scores of citation impact as a result.

Specifically, we aim to study the following questions: are medical students who publish before graduation: 1) more likely to publish after graduation, 2) do they publish a greater number of papers after graduation, and 3) do they publish papers with a higher citation impact after graduation? If the answers to these questions are positive, authentic research learning opportunities during medical training and the opportunity to publish scientific work could impact students' interest in a research career.

Methods

All 2005-2008 MD graduates from all eight Dutch university medical centres were included in the study. All eight agreed to participate and provided the names of their graduates. With 1658 graduates in 2005, 1832 graduates in 2006, 1990 graduates in 2007, and 2064 graduates in 2008 this study includes 7544 medical graduates. The study was approved by the Educational Institutional Review Board of Leiden University Medical Center (reference number OEC/ER7RC/20171212/1) on 12 December 2017.

In the Netherlands, in 2005-2008, medical school comprised 6 years of study, of which 4 years were pre-clinical and 2 years were clinical training. Students typically start medical school directly after finishing secondary school, which means that the majority of students are approximately 18-19 years old when starting medical school and they have not previously obtained an undergraduate degree.[21] Partly because of the nature of the medical school system, MD/PhD programmes in the Anglo-Saxon tradition are virtually absent. Such programmes do exist but typically only draw fewer than twenty medical students. When medical students pursue a PhD degree, they usually do so after MD graduation (either full-time or in combination with postgraduate medical specialty training). All eight medical schools provide scientific training in line with the national Blueprint for Medical Education,[3] including a compulsory full-time individual research project of at least 14 weeks in pre-clinical training.

The names of the MD graduates were matched to their publications indexed in the Centre for Science and Technologies Studies in-house version of the Web of Science database (database version complete up until week 13 of 2017). A common problem in such matches is the false-positive assignment of papers (papers that were not written by a person but still attributed to them) and false-negative assignment (papers not attributed to a person that *were* written by them). A false-positive assignment mainly results from homonyms: names shared by multiple persons. Especially in the case of common names and few initials, there is a considerable chance that a publication was not authored by the graduate in question. False negatives can occur due to spelling errors, missing initials, and changing names related to marriage or divorce. To prevent false positives and negatives, one could manually try to check all publication assignments. However, this was not feasible in our case. Our study includes 7544 graduates, of which a considerable number were expected to have published many papers after graduation.

Therefore, we employed two complementary strategies. We automatically assigned publications to a subset of all graduates with relatively rare names, a strategy also employed in other studies.[22,23] Additionally, we manually assigned publications to a 10% random sample from this group. We selected rare names based on the number of initials and the prevalence of the last name in the Web of Science (the number of unique combinations of last name and initials). We selected all graduates with three or more initials and a last name occurring in less than 1000 unique combinations of last names and initials, and with two initials and a last name occurring in fewer than 50 unique combinations. This resulted in a set of 4145 (out of 7544) MD graduates. In addition, we used an author clustering algorithm developed by the Centre for Science and Technologies Studies.[24] The algorithm sorts all publications in the Web of Science into clusters of publications presumed to be authored by the same person. We matched the graduates' full names (last name plus all initials) to the most common full name in an author cluster. This decreases the chance of false-positive assignment, as all initials have to match. To further decrease this chance, the first publication in the cluster also had to be published between 6 years before (as it is quite unlikely that a medical student would publish before starting their studies) and 6 years after graduation. From the clusters we collected all articles, reviews, and letters published between 6 years pre-graduation and 6 years post-graduation. This has the added benefit that also papers on which students did not use all their initials are collected, which decreases the chance of false-negative assignment (of course as long as they have other publications with all initials listed).

As a measure of citation impact after graduation, we used the mean normalized citation score of the papers published after graduation.[25] We counted the number of citations to each paper between the year of publication and two years afterwards. Papers were counted fully, i.e., each paper counts equally, regardless of whether it was authored by one or multiple authors. The citation score was then normalized by scientific field, as the number of citations that publications receive is greater in some fields than in others.[25] By definition, the normalized citation score of a field is 1; a score higher than 1.2 is considered to be above field average, a score below 0.8 lower than field average.

For statistical analyses we used SPSS Statistics version 23.0.0 (IBM). To test whether group differences were statistically significant, we used 1) the chi-square test for the likelihood to publish after graduation, 2) the Mann-Whitney U test for the number of papers published after graduation (as data were not normally distributed nor could be transformed to become normally distributed), and 3) an independent samples t-test for the mean normalized citation impact (MNCS; Box-Cox transformed with $\lambda=0.75$ to follow normal distribution).

Results

Likelihood to publish before and after MD degree

The analysis of pre- and post-graduation publication activity after automatic publication assignment showed that 518 graduates published one or more papers before or in the year of graduation (12%); 1591 graduates published after graduation (38%; Table 1). The relative risk of pre-graduation publication for post-graduation publication was 1.90 ($c^2 = 185.91$, 95% CI [1.76, 2.05], $p < 0.001$), which shows that MD graduates who published before graduation were almost twice as likely to publish after graduation than graduates who had not. The manual assignment of a 10% random sample of graduates ($n = 414$) with rare names showed a slightly higher number of graduates with publications. The difference lay especially in graduates who only published post-graduation. In total, manual assignment assigned publications to 32 graduates that automatic assignment did not (8%). In 27 cases, this was due to graduates publishing with fewer initials than listed in the faculty administration database, in four cases a double last name was abbreviated, and in one case the author clustering algorithm had falsely assigned a graduate's publication to another author's cluster. Automatic assignment did not assign any publications that those assigned manually. Manual assignment showed 60 out of 414 graduates had published one or more papers before or in the year of graduation (14%); 192 published after graduation (46%). The relative risk was 1.60 ($c^2 = 13.60$, 95% CI [1.30, 1.98], $p < 0.001$).

6

Number of post-graduation publications

Next, we assessed whether students who published before graduation published more papers after graduation than those who did not. In total, 38% of all graduates published one or more papers after graduation. The number was heavily skewed, as of these 38%, almost a third (31%) published only one paper after graduation.

Table 1. Number of MD graduates with publications before and after graduation (graduates with rare names only)

	Publication after graduation[b]		
Publication before graduation[a]	Yes	No	Total
Yes	340	178	518
No	1,251	2,376	3,627
Total	1,591	2,554	4,145

[a] Before graduation: between six years before or in the year of graduation.
[b] After graduation: between one and six years after the year of graduation.

The comparison between the groups shows that for students without one or more publications before graduation, the distribution was heavily skewed to the right (Fig. 1, bottom panel), whereas this distribution was less skewed for graduates with one or more pre-graduation publications using automatic assignment (Fig. 1, top panel). The difference in the number of post-graduation publications was statistically significant (Mann–Whitney U = 1,282,058, $n1$ = 518, $n2$ = 3,627, $p < 0.001$ two-tailed). This is reflected in the mean number of papers published after graduation (striped line): this is 5.01 for students with pre-graduation publications (top left panel) and 1.73 for students without pre-graduation publications (bottom left panel).

The results of manual assignment again differed slightly from the results of automatic assignment. Results from manual assignment showed the mean number of publications after graduation to be 4.75 for students with pre-graduation publications (cf. 5.01 in automatic assignment) and 2.16 for students without (cf. 1.73 in automatic assignment). The distributions differed statistically significantly between the groups (Mann–Whitney U = 14,184.500, $n1$ = 60, $n2$ = 354, $p < 0.001$ two-tailed).

Post-graduation citation impact

Next, we determined whether the mean citation impact of students who published before graduation differed from that of students who did not. We compared the distribution and mean of the MNCSs between students who had and had not published before graduation.

Automatic assignment showed that students who published before graduation tended to have a greater mean citation impact. The mean difference was statistically significant ($t(1{,}591) = -2.81$, 95% CI [-0.32, -0.06], $p = 0.005$ on Box-Cox transformed MNCS). In addition, the average of their MNCSs was higher (1.33) than that of students who did not publish before graduation (1.13). Manual assignment showed that the average MNCS of students who published before graduation was 1.12; of students who did not publish before graduation it was 1.02. This means that the MNCS of the two groups did not differ statistically significantly using manual assignment ($t(151) = -0.61$, 95% CI [-0.43, 0.22], $p = 0.54$ on Box-Cox transformed MNCS).

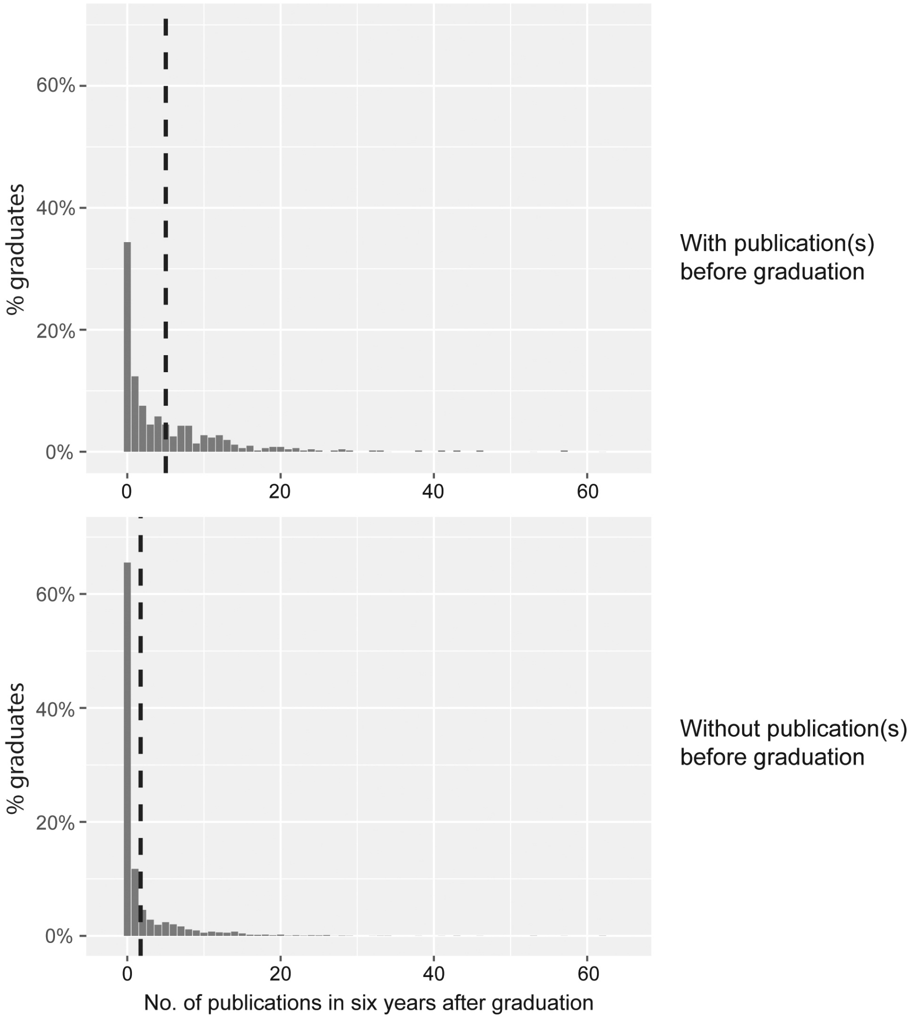

Figure 1. Histogram of number of publications published in 6 years after graduation by pre-graduation publication (by students with rare names). The striped line represents the mean number of publications in the 6 years after graduation for each group. Before graduation: between 6 years before or in the year of graduation.

6

Discussion

In this study, we found that medical students who published during their studies were almost twice as likely to publish after graduation, and published more papers after graduation. We also found these medical students had a slightly higher citation impact, albeit this was not statistically significant in the smaller group of manual publication assignment. This means that the early engagement of medical students in research leading to scientific publication is positively associated with sustained publication after MD graduation. Whereas this relationship may seem straightforward, no study has looked at the strength of this association before by using bibliometric methods. In addition, many studies on this topic have intended research involvement or interest in a research career as dependent variable rather than measures of actual research involvement.[18-20] It is important to note that within the studied group of medical students, all students had been required to undertake a full-time individual research project of at least 14 weeks in pre-clinical training.[3] This means that rather than looking at the effect of undertaking a research project versus not undertaking such a project, we compared students who had published before graduation, which reflects an experience of success, to those who had not. In the comparison between these groups, we found that pre-graduation publication was associated with sustained publication, a higher number of publications and higher citation impact after graduation.

Social Cognitive Career Theory, and especially its key concept of self-efficacy, could explain why such a positive association exists.[26] Mastery of an activity leads to higher self-efficacy.[27] Early involvement in research leading to the publication of a student's scientific work could increase research self-efficacy,[20,28] which could be an explanation of our results. The effect of a success experience during medical school is not the only possible explanation of the association we found, though, as the effect of self-efficacy is not limited to the period of medical training. Career interests already develop during childhood and adolescence.[26] Certain medical students could thus have developed a greater interest in research than others already before starting medical training.[20] If these students publish more often before and after graduation, it is a confounder of the association we found between pre-graduation and post-graduation publication.

Other explanations of the association we found are the extrinsic motivation to conduct research and selection effects. A previous study by our group showed that medical students have a high extrinsic motivation to do research, already in their first year.

They expect it to improve their chances for their preferred residency spot.[10] A selection effect is at play if PhD advisors prefer to hire the recent MD graduates who have published during their studies as PhD candidates; this could also contribute to the association we discovered.

On a more general level, our results show that quite a number of medical students in the Netherlands published one or more papers in the 6 years after graduation: 1591 out of 4145, which is 38%. This finding seems to disprove the physician-scientist shortage often reported upon,[4-8] and which we mentioned in the introduction. At the same time, we also noted in our Results section that the distribution of the number of publications is heavily skewed. Of the 38% who published after publication, almost one-third (31%) published only one paper. These graduates do not appear to have remained active physician-scientists after graduation. In addition, the selection system for medical specialty residencies may have increased the number of graduates with post-graduation publications. As mentioned above, medical students are quite extrinsically motivated to pursue a PhD degree because it will increase their chances of a residency spot. It will therefore be interesting to repeat our study in a few years' time to see how many medical graduates remain scientifically active after the period of residency spot competition has ended. Then, this basis for extrinsic motivation will have disappeared while other barriers to academic career involvement are still present, such as difficulties combining research, clinical care, and family and personal life.[29,30]

Limitations and strengths

Naturally, our study comes with limitations, the first of which is that it only measures scientific output, both before and after graduation, due to its reliance on bibliometric methods. However, medical students and graduates may be engaged in research without that engagement leading to a publication. Case in point are the students in our studied sample who had not published before graduation. Medical school requirements in the Netherlands include a compulsory research project of at least 14 weeks,[3] so these students have been involved in research but it has not led to publication.

A second limitation is that we performed an observational study and cannot infer an independent, causal effect of early scientific publication on the scientific career after graduation. For example, the aforementioned confounding effect of medical students who published before graduation possibly already having a greater interest in research than students who did not through their experiences in childhood and adolescence, may be at play.[20,26] There is also the aforementioned selection effect of PhD advisors preferably hiring MD graduates who have published during their studies as PhD candidates. At the same time, from our results we *are* able to conclude that medical students who publish before graduation are more likely to be involved in research after graduation, publish more papers and have a slightly higher citation impact. This is regardless of whether that is because they had a greater interest in research, were more motivated, had higher research self-efficacy in the first place, were hired more often as PhD candidates, or whether the successful publication of their scientific work had a direct effect on them.

A third limitation is that the choice of bibliographic assignment (manual or automatic) affects the exact results. In a previous study by our group, we found 15% of medical students had published in the 3 years before graduation, using manual publication assignment.[31] Using manual assignment of a 10% random sample in the present study, we found a similar percentage, 14%, had published before graduation, whereas automatic assignment showed 12% of students had published in the 6 years before graduation. The discrepancy is mainly due the fact that manual assignment more easily assigns publications on which not all initials were listed.

Author clustering algorithms perform better when more information is available (including assigning publications to a cluster even when the initials do not match exactly) – this is more often the case for the prolific pre-graduation publishers who, as our study shows, publish more papers after graduation. Therefore, automatic assignment slightly underestimates the number of published papers, but more so for students who only published after graduation. Compared with manual assignment, this leads to a slight overestimation of both the relative risk of publishing after graduation by pre-graduation publication as well as a small overestimation of the difference in the number of post-graduation publications. Citation impact analysis using manual assignment *did* show material differences to automatic assignment. Not only was the average MNCS lower for all students, there was no statistically significant difference in citation impact between students with and without pre-graduation publications. However, manual assignment suffers from drawbacks, too, such as a certain subjectivity. For example, a currently active physician-scientist often has a stronger online presence than a graduate with only one publication after graduation. In manual assignment, one would more easily assign publications to the former than the latter.

At the same time, this limitation could also be considered a strength. Although the exact results vary by choice of method, our overall conclusions of medical graduates publishing before graduation having a higher chance of publishing after graduation and publishing more papers are unaffected by the choice of method.

Another strength is that the employed bibliometric methods enabled us to study a large set of 4145 MD graduates in the Netherlands and their publications published in a 13-year period. Bibliographic assignment of publications to students is not a trivial exercise. Bierer and colleagues indicated as such in their 2015 study on the relationship between research self-efficacy and scholarship of medical students, in which they studied 248 graduates and their publications published during medical school and within 6 months after graduation.[19]

Conclusion

As mentioned in our introduction, there is currently a shortage of physician-scientists.[4-8] Medical students who publish during their studies are more likely to keep publishing after graduation, are more productive, and have a higher citation impact. Although this association could also be caused by other factors, there is good reason to assume that the association is at least partly caused by the success experience that publication during medical school gives students.[19,20] Medical schools could alleviate the physician-scientist shortage by providing students with more opportunities for authentic research experiences during medical training, including the opportunity to gain experience in the scientific publication process.

In conclusion, when it comes to early scientific publication by medical students, what is learnt in the 'cradle' indeed lasts. Although we cannot infer from our results whether it lasts until the tomb, we do know it lasts at least during the 6-year period after graduation.

References

1. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
2. Swing SR. The ACGME outcome project: retrospective and prospective. *Medical Teacher.* 2007;29(7):648-654.
3. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009.* Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
4. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
5. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
6. Ley TJ, Rosenberg LE. The physician-scientist career pipeline in 2005: build it, and they will come. *Jama*. 2005;294(11):1343-1351.
7. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
8. Sheridan DJ. Reversing the decline of academic medicine in Europe. *Lancet*. 2006;367(9523):1698-1701.
9. DeLuca GC, Ovseiko PV, Buchan AM. Personalized medical education: Reappraising clinician-scientist training. *Science translational medicine*. 2016;8(321):321fs322-321fs322.
10. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education*. 2018;7:248-255.
11. Healey M, Jenkins A. *Developing undergraduate research and inquiry*. York: Higher Education Academy; 2009.
12. Waldrop MM. Why we are teaching science wrong, and how to make it right. *Nature*. 2015;523(7560):272-274.
13. Frishman WH. Student research projects and theses: should they be a requirement for medical school graduation? *Congenital Heart Disease*. 2001;3(3):140-144.
14. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.
15. Vereijken MWC, van der Rijst RM, van Driel JH, Dekker FW. Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. *Advances in health sciences education: theory and practice*. 2018;23(2):371-385.
16. Andriole DA, Jeffe DB. Predictors of full-time faculty appointment among MD-PhD program graduates: a national cohort study. *Medical Education Online*. 2016;21:30941.
17. Bierer SB, Chen HC. How to Measure Success: The Impact of Scholarly Concentrations on Students-A Literature Review. *Academic Medicine*. 2010;85(3):438-452.
18. Skinnider MA, Twa DD, Squair JW, Rosenblum ND, Lukac CD, Group CMPPI. Predictors of sustained research involvement among MD/PhD programme graduates. *Medical Education*. 2018;52(5):536-545.
19. Bierer SB, Prayson RA, Dannefer EF. Association of research self-efficacy with medical student career interests, specialization, and scholarship: a case study. *Advances in health sciences education: theory and practice*. 2015;20(2):339-354.

20. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine.*. 2017;65(5):942-948.
21. Ten Cate O. Medical education in the Netherlands. *Medical Teacher.* 2007;29(8):752-757.
22. Boyack KW, R. K. Measuring science-technology interaction using rare inventor-author names. *Journal of Informetrics*. 2008;2:173-182.
23. Waaijer CJF, Macaluso B, Sugimoto CR, Lariviere V. Stability and Longevity in the Publication Careers of U.S. Doctorate Recipients. *PloS one.* 2016;11(4):e0154741.
24. Caron E, van Eck N-J. Large scale authorname disambiguation using rule-basedscoring and clustering. In: E. N, ed. *International conference on science and technology indicators.* Leiden: Centre for Science and Technology Studies; 2014:79-86.
25. Waltman L, van Eck NJ, van Leeuwen TN, Visser MS, van Raan AF. Towards a new crown indicator: an empirical analysis. *Scientometrics.* 2011;87(3):467-481.
26. Lent RW, Brown SD, Hackett G. Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *Journal of Vocational Behavior.* 1994;45(1):79-122.
27. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.
28. Phillips JC, Russell RK. Research self-efficacy, the research training environment, and research productivity among graduate-students in counseling psychology. *The Counseling Psychologist.* 1994;22:628-641.
29. Salata RA, Geraci MW, Rockey DC, et al. U.S. Physician-Scientist Workforce in the 21st Century: Recommendations to Attract and Sustain the Pipeline. *Academic Medicine.* 2018;93(4):565-573.
30. Cox AL. Balancing Research, Teaching, Clinical Care, and Family: Can Physician-Scientists Have it All? *Journal of Infectious Diseases*. 2018;218:S32-S35.
31. van Eyk HJ, Hooiveld MHW, Van Leeuwen TN, et al. Scientific output of Dutch medical students. *Medical Teacher.* 2010;32(3):231-235.

7

Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency

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Perspectives on Medical Education, 2017

In this issue, Gupta and colleagues present interesting results on whether medical students who have written a scientific paper have a higher chance of being selected for a residency spot in paediatrics.[1] Before addressing the findings of their study and contemplating on extrinsic versus intrinsic motivation for conducting research, we would like to take a step back and elaborate on the overall importance of scientific training in medicine.

According to the CanMEDS, the core competencies of a scholar consist of two distinct elements: being able to *use* and being able to *conduct* research. This distinction between using and conducting research has also been adopted in the 2009 blueprint for medical education in the Netherlands.[2]

Using research applies to all physicians, as every physician should be able to understand and use research to integrate scientific knowledge in clinical practice and form grounded diagnosis.[3,4] Involving scientific knowledge in clinical decisions requires physicians to keep up-to-date with the newest developments in medicine. Also, they should be able to critically appraise scientific literature and discuss research findings both with colleagues, and with patients who have better access to information from the internet than in the past.[5,6] Moreover, using research can also be seen as a contribution to the process of life-long learning, continuously translating new knowledge into patient care.[7]

In addition to all physicians utilizing research, medical education also intends to cultivate some physicians who will *conduct* research. These physician-scientists are needed to make progress in the continuously evolving field of medicine and to form a bridge between science and practice, by translating research outcomes into clinical settings. Furthermore, physician-scientists have the ability to identify relevant clinical questions and problems. By being actively engaged in clinical practice, these physician-scientists encounter daily clinical questions and problems, which can serve as inspiration for scientific research. Moreover, physician-scientists can contribute to developing new knowledge by formulating research questions, thinking about proper study designs, contributing to data collection and interpretation of results, and writing scientific papers. They can also develop clinical guidelines, and are role models by implementing this new knowledge into clinical practice.[8,9]. In this process of translational research, back and forth from ‘bench to bedside’, physician-scientists are key. However, in the last decade concerns have been raised about the declining number of physician-scientists in many countries.[3,10,11]

In order to train all physicians to reach the required level of a scholar, and also to counteract the decline of the physician-scientist workforce, scientific training must play an important role in medical education. This can be established in two ways. The first is by engaging students with talents and ambition into extracurricular research programmes. Examples of these extracurricular research programmes are MD/PhD programmes and scholarly concentration programmes, the latter becoming a common method within the field of medical education.[12,13] The second is by integrating research into medical curricula in a way that it reaches all medical students.[7] We believe that acquainting students with both using and conducting research should already be clear goals in the early phases of medical education. Actually conducting research can help students to understand and use research, while at the same time this offers an opportunity to shed light on a possible research-oriented career. Also, it helps to recognize talented students and helps them develop into the next generation of physician-scientists.

Healey and his colleagues have developed a framework to illustrate the research-teaching nexus and explain four ways in which students in higher education can experience research in the curriculum. According to this framework, students can be viewed as audience or as active participants, while the emphasis can be on the research process or on research content. It has been argued that viewing students as participants, combined with an emphasis on the research content, is a form of active learning.[14] Active learning, or 'learning by doing', is seen as the most optimal way to engage students in this kind of activity.[15-17] This can be established, for instance, by offering students the opportunity to conduct or participate in an authentic research project during their medical training. In this respect, the hands-on experience of publishing a scientific paper may well be seen as an excellent example of active learning, and thus would be a powerful means to cultivate scientific minds.

In this issue, Gupta and colleagues show thought-provoking research findings, which indicate that pre-residency publication is not associated with achieving a higher rank in first-choice match for paediatric residency in Canada. From this, they conclude that extrinsic motivation should not be the main driving factor for doing research and publishing a paper, as apparently a published paper does not help to get a higher ranking. They also argue that educators should be honest about this to students and adapt the information communicated towards them.[1] Of course, the question can be raised whether these findings tell us something about the intrinsic value of writing a publication in medical training? Perhaps they tell us more about the selection procedure in this specific paediatric setting in Canada, and the weight given to publications by selection committees, which can vary between specialties and even countries. Imagine what could happen if medical students were to read Gupta's paper and indeed no longer have the ambition to do research and publish a paper? Or, the other way around, what if students who are interested in doing research no longer apply for a residency in paediatrics? What might be the consequences for the scientific image of paediatrics and other specialties alike?

Nevertheless, as educators we are happy to see that extrinsic motivation for doing research should be less important for medical students, making room for developing sincere intrinsic motivation. In line with this, we would like to cordially invite educators to emphasize the importance of research for the future of clinical practice and patients, thereby fostering the intrinsic motivation of these students. Studies based on the Self-Determination Theory have shown that intrinsic motivation is related to better academic performance and general wellbeing.[18,19] Hence, educators should aim to stimulate students' intrinsic motivation. However, we can imagine that students tend to start participating in research because of extrinsic motivators, such as the belief that conducting research will secure a competitive residency spot or broaden their future career options.[3,20-22] This notion of the importance of research seems logical, as many educators emphasize the need to do something extra to students from the beginning of medical training.

But is conducting research because of these extrinsic incentives always bad? Could it be that students are extrinsically motivated when they start conducting research, but become intrinsically motivated along the way? Perhaps students become more and more familiar with the ins and outs of research, and discover how much fun it is to do. By engaging in research, students could also discover their own talents and research competencies, which contributes to their intrinsic motivation for research. For instance, experiencing research could enhance students' research self-efficacy over time, and according to Bandura's Social Cognitive Theory enhanced self-efficacy influences intrinsic motivation.[23] This is in line with one component of the Self-Determination Theory, which states that perceived competence of a person is related to his or her intrinsic motivation. Moreover, students can shift in the continuum of the different types of motivation, as also described by the Self-Determination Theory.[18,19] Thus, it seems fair to assume that a process of transitioning extrinsic motivation into intrinsic motivation over time is possible. Before students are discouraged from doing research because it probably has no value in gaining a residency spot or a first match outcome, we believe it is of great importance to investigate whether this extrinsic motivation to do research can indeed turn into feelings of intrinsic motivation while being actively engaged in research.

In conclusion, we would like to emphasize the great importance of directing a sufficient number of medical students towards a research-oriented career. This could help to avoid a further decline in physician-scientists and thereby contribute to the next generation of physician-scientists that is so urgently needed in our world of medicine. It would be unfortunate for every specialty, including paediatrics, if students were to engage less and less in research before entering residency. Therefore, dealing with the intrinsic *and* extrinsic feelings of students towards research in such a way that could trigger their intrinsic motivation for research could be of great value.

References

1. Gupta R, Norris ML, Barrowman N, Writer H. Pre-residency publication and its association with paediatric residency match outcome-a retrospective analysis of a national database. *Perspectives on Medical Education*. 2017;6(6):388-395.
2. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009.* Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
3. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
4. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
5. Ilic D. The role of the internet on patient knowledge management, education, and decision-making. *Telemedicine and e-Health*. 2010;16(6):664-669.
6. McMullan M. Patients using the Internet to obtain health information: how this affects the patient–health professional relationship. *Patient education and counseling*. 2006;63(1):24-28.
7. de Beaufort AJ, de Goeij AFPM. Academic and scientific education in medical curricula in the Netherlands: a programme director's view. *Perspectives on Medical Education*. 2013;2(4):225-229.
8. Harding CV, Akabas MH, Andersen OS. History and Outcomes of 50 Years of Physician-Scientist Training in Medical Scientist Training Programs. *Academic Medicine*. 2017.
9. Dekker FW. Achieving research competences through medical education. *Perspectives on Medical Education*. 2013;2(4):178-180.
10. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
11. Hall AK, Mills SL, Lund PK. Clinician-Investigator Training and the Need to Pilot New Approaches to Recruiting and Retaining This Workforce. *Academic Medicine*. 2017.
12. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.
13. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
14. Healey M, Jordan F, Pell B, Short C. The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International*. 2010;47(2):235-246.
15. Janmaat VT, Kortekaas KE, Moerland TM, et al. Tutored Learning: An Effective Way for Students to Benefit Research by Critical Appraisal. *Medical Science Educator*. 2013;2(23):269-277.
16. Lazonder AW, Harmsen R. Meta-Analysis of Inquiry-Based Learning: Effects of Guidance. *Review of Educational Research*. 2016;86(3):681-718.
17. Jenkins A. *Reshaping teaching in higher education: Linking teaching with research*. Psychology Press; 2003.
18. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.

19. Ten Cate TJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. *Medical Teacher.* 2011;33(12):961-973.

20. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine.* 2017.

21. Mina S, Mostafa S, Albarqawi HT, et al. Perceived influential factors toward participation in undergraduate research activities among medical students at Alfaisal University-College of Medicine: A Saudi Arabian perspective. *Medical Teacher.* 2016;38:S31-S36.

22. Abu-Zaid A. Research skills: the neglected competency in tomorrow's 21st-century doctors. *Perspectives on Medical Education*. 2014;3:63-65.

23. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.

8

Using an extracurricular Honours programme to engage future physicians into scientific research in early stages of medical training

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Abstract

Physician-scientists are urgently needed to make progress in the dynamic world of medical healthcare. Currently, there is a worldwide shortage in physicians pursuing a scientific career. Actively engaging students in research in early stages of medical training could help to direct students towards a scientific career and contribute to creating the next generation of physician-scientists. Leiden University Medical Center (LUMC) implemented an extracurricular Honours programme with a fundamental orientation towards research. The programme starts in the second year of medical training and is comprised of four different tracks in order to attract multiple types of students with different interests. All four tracks offer students scholarly experiences, but differ in content and amount of provided structure. The LUMC Honours programme has a clear goal to develop future physician-scientists, and combined with its unique multiple-track model, the programme accommodates about 70 students (25%) each year. The number of students in the programme has grown and students' experiences are positive.

Background

The Canadian Medical Education Directives for Specialists (CanMEDS) distinguishes being able to use and being able to conduct research as two core competencies of a scholar.[1] A common belief in the medical field is that all physicians should be able to use research, which is important in forming evidence-based decisions and making a grounded diagnosis.[2-5] In order to integrate scientific knowledge in clinical decisions and to ensure that patients receive the best possible healthcare, physicians should be aware of the latest developments in medicine. Being able to critically appraise scientific literature is key in the process of using research in daily clinical practice.[6]

However, besides all physicians using research, physicians who actually conduct research are needed as well. These physicians are needed because it is important to create new knowledge to make progress in the demanding world of medical healthcare.[3,4,6,7] Physicians combining clinical work with doing research in the medical context are called physician-scientists. Physician-scientists offer an opportunity to bridge the gap between science and clinical practice.[8-10] They have the opportunity to identify clinical problems in daily practice, which can be translated into research questions and designs.[11] Subsequently, physician-scientists can translate research outcomes into clinical practice.[12]

Currently, there is a global shortage in the number of physician-scientists, with too few physicians pursuing a scientific career.[2,8,10,13,14] A decline in interest for research among physicians in Canada, the United States, and Europe has been documented.[2] How physicians can be directed towards a scientific career is still a topic of debate, although early engagement of medical students in research is mentioned as a possible solution.[2,6,7,15-18] Engaging students in research in early stages of medical education could help to identify a possible scientific career path for these future physicians, as it could trigger enthusiasm and motivation for doing research.[4] This view is shared internationally, as is reflected in the growing amount of curricular and extracurricular courses to engage students in research.[2,19]

Some medical schools have designed and implemented mandatory courses in the curriculum with the goal to get students acquainted with research, for instance Duke University implemented a mandatory period of research into the third year of the medical curriculum, and Stanford University integrated mandatory research experiences for medical students through all years of medical training.[19,20] Leiden University Medical Center (LUMC) implemented a curriculum change in 2012, integrating mandatory research courses in undergraduate medical training with the purpose to engage students in research in early phases of medical training by providing them with active learning experiences.[21]

Besides mandatory courses in the curriculum, a trend is evolving in which medical schools design and implement extracurricular research programmes with the aim to involve students in research. These research based programmes occur in very different ways and under different names, but share a mutual goal to expose students to in-depth inquiry and research experiences with capstone projects like writing a thesis or a publishable article. Such extracurricular research programmes occur as, for instance, MD/PhD programmes, scholarly concentration programmes, Capstone programmes, Summer Research programmes, and Honours programmes.[19,22,23] LUMC designed and implemented an extracurricular research based Honours programme to engage students in research. The aim of this monograph is to provide a detailed description of the LUMC Honours programme to act as reference or inspiration for other medical schools exploring options to implement an extracurricular research based programme.

The medical Honours programme of the LUMC

As a faculty that is part of a research intensive university, the LUMC emphasizes the importance of research and educating future physician-scientists. Therefore, one of the goals of medical training is to stimulate students to become familiar with and engage in research. Students of the LUMC follow mandatory courses throughout all years of medical training, in which the students are actively engaged in doing small-scale research projects.[21,24,25] Next to these mandatory courses, the LUMC offers an extracurricular Honours programme for bachelor students with a fundamental orientation towards research.

The medical Honours programme of the LUMC differs from traditional Honours programmes in its design and main goal, as the programme originated from a point of view that future physician-scientists are needed. Hence, the programme is largely devoted to make the first step to cultivate the next generation of physician-scientists.

The LUMC programme can be seen as an extracurricular research programme, internationally similar to earlier mentioned 'scholarly concentration programmes'.[22] The LUMC Honours programme has a relatively large capacity to accommodate students and focuses on providing them with scholarly experiences. It is an extracurricular two-year programme and it has a minimum of 30 ECTS (ECTS = European Credit Transfer and Accumulation System), which means that students have to invest 30 x 28 hours of active study. The programme gives students the opportunity to experience research in an authentic learning situation by actually designing and implementing their own research in one of the departments of the LUMC.

The programme starts with an optional orientation phase in the first year of the medical study. All first-year medical students are invited to participate in this orientation phase, which is already unique, as most Honours programmes only target so called 'excellent' students.[26] The orientation phase consists of multiple expert lectures covering the different (bio)medical research areas of the LUMC. These lectures are given by highly experienced physician-scientists. This allows students to become familiar with and inspired by research and research-related work, and to get to know the career opportunities as future physician-scientists. The number of students who use this opportunity and are actively involved in the orientation phase differs every lecture, ranging from 30 to 150 out of approximately 300 students in total. Students participating in the orientation phase are provided with a possibility to earn some credits for the actual Honours programme, prior to the official start in the second year of medical training. Students participating in the orientation phase can choose to submit written reports of the expert lectures (in English), summarising their content and adding new knowledge from recent literature. The reports are graded by educators specialised in academic writing, scoring students both on content and academic English. If students receive a passing grade for at least four of the meetings, they already earn two credits (2 ECTS) for the Honours programme, before the official programme has even started. After this, students can choose to earn another credit (1 ECTS) by interviewing one or more post-docs and/or PhD students. Students are asked to make a scientific report on the content and outcomes of the interviews, which again will be graded by educators specialised in academic writing. These interviews provide the students with an even better impression of the ins and outs of performing research.

The orientation phase starts in November and ends in June of the first year of medical study. Students are not obligated to actively participate in the orientation phase, they can still participate in the actual Honours programme regardless. By and large, the main goal of the orientation phase is to offer students the possibility to get acquainted with research and the programme, and to help students decide if the Honours programme seems to be a good fit for them as an extracurricular activity during medical training.

During the summer break between the first and the second year of medical training students need to decide whether they would like to participate in the actual Honours programme starting in September. They can officially apply during the summer months. The selection for the programme is largely based on self-selection of the student, as three of the four tracks are open to different types of students without having institutional selection criteria. The MD/PhD track is the only track with limited availability, resulting in institutional selection focusing on high grades. Although the selection of the MD/PhD track is comparable to most regular Honours programmes, the self-selection of students in the other three tracks is a second factor distinguishing this programme from regular Honours programmes.

Four-track model of the Honours programme

The Honours programme at the LUMC provides four different tracks to attract multiple types of students with different interests. At the start of the programme, the student can choose between one of the following four tracks: the MD/PhD track, the Journey into Biomedical Sciences track, the Clinical Research/Epidemiology track, and the Free Research track. The four tracks are different in content and approach, but they share a fundamental orientation towards research. The distribution of students among the four tracks at the start of the programme in the years 2013-2016 is illustrated in table 1.

The *MD/PhD track* prepares the student for, and could be the beginning of, a future PhD project. Although every track can be a foundation for a future PhD project, the MD/PhD track explicitly acknowledges this as its main goal. The track has a limited capacity, accommodating only ten students every year. Students are selected by the institution, thus in this regard the track is comparable to regular Honours programmes. Students are selected based on academic performance, curriculum vitae, and motivation.

Table 1. Overview of participating Honours students in 2013, 2014, 2015, and 2016

	2013	2014	2015	2016
Medical students	275	265	306	299
Honours students	59	64	72	81
MD/PhD	10	10	10	10
Journey into Biomedical Sciences	13	17	15	18
Clinical Research/Epidemiology	17	15	28	25
Free Research	19	22	19	28

The selected students are free to choose a department, and autonomous in choosing their research topic. The coordinator of the Honours programme and the supervisor from the department assist the student in making these choices. The department coaches the student in the same way as it would coach a regular PhD candidate. Next to their bachelor studies, students have the opportunity to perform research and to write at least two scientific papers for their future PhD thesis.

The *Journey into Biomedical Sciences track* is a programme for students who would like to acquire a deeper understanding of biomedical sciences and it offers an opportunity to follow a programme with a fundamental orientation towards biomedical research. Both the first and second year of this track focuses on theory and laboratory skills, and upon completion gives the student the opportunity to combine the Medicine master and the Biomedical Sciences master in Leiden. Main subjects of this track are cellular communication, medical genetics, and immunology in the first year, and Molecular Biology and Oncology, communication in science, writing a review, and acquiring and application of laboratory skills in the second year.

8

The *Clinical Research/Epidemiology track* offers both the opportunity to participate in courses about clinical epidemiology and statistics, and the possibility to do a clinical research project. Students can choose what kind of clinical research they would like to do and are mentored by a senior researcher of the department. An example of a course in this track is 'Introduction in Clinical Scientific Research', where students get to know the different departments of the LUMC. This is a popular course and it helps students with the orientation towards a specific department, where they could possibly do their research. Another course of this track gives an introduction in epidemiology by discussing the book of Kenneth Rothman ("Epidemiology, an introduction").[27] The Clinical Research/Epidemiology track also offers an opportunity to follow a 5-day masterclass course in clinical epidemiology, in which students are educated in content identical to the education of PhD candidates and clinical researchers. In both the first and the second year of this track the student will actively participate in doing research.

The last track is the *Free Research track*, which offers students the possibility to do a research project in a department of their own choice. This track seems suitable for two types of students. First, this track appeals to students who are eager to do research, but who are not yet ready for long term commitment, as they are still curious to find out which type of research and (bio)medical research area suits them best. Second, this track is also attractive for students who already decided what kind of research they want to do and at what department, committed to doing their own research in one particular area. The Free Research track offers these students the possibility to devote their Honours programme to conducting their own research at one department.

In contrast to the MD/PhD track, the other tracks are mostly self-selected. Notably, the Honours programme of the LUMC is designed with maximum flexibility for the participating students. If students come up with an individualised plan to earn their 30 credit points, they can approach the Honours coordinator to discuss the possibilities. Additionally to earning credits in any of the four tracks or from the alternative propositions, all students are required to follow at least one Honours Class of 5 ECTS offered by the University of Leiden. The Honours Classes of all Leiden Faculties are coordinated by the Honours Academy Leiden, and are always interdisciplinary by nature. Most of the Honours Classes are in in English, and are aimed at broadening students' intellectual horizon. There is a great variation in the offered Honours Classes and the students are free to choose whether they prefer to follow an Honours Class in their second or third year. Summing up, to receive an Honours Certificate students need to have earned 30 ECTS, followed an Honours Class, and passed all the courses in the regular curriculum.

Outcomes of the LUMC Honours programme

The LUMC Honours programme is fundamentally orientated towards research and has the clear goal to develop future physician-scientists. The relative large capacity, self-selection, and four different tracks to address different types of students contribute to the uniqueness of the programme as compared to other, more traditional, Honours programmes. Designing an Honours programme in this way seems to be attractive for students, as is reflected in the increasing number of participating students over the last few years. From the programme's inception with about 20 students participating in 2010, nowadays the programme provides extracurricular research activities for 81 medical students in 2016 (Table 1). This number represents 27.1% of one yearly cohort. Most of the extracurricular Honours programmes provide only places for few students, so having 27.1% of all students in a year participating in an extracurricular programme is truly exceptional.

Students of the LUMC Honours programme were surveyed in 2016 to evaluate the programme and its four different tracks (n = 97). A total of 136 Honours students were approached, of whom 97 students participated (71.3%) and anonymously filled out a digital questionnaire regarding their experiences in the programme. Students from both years of the programme and all four different tracks were included. The sample consisted out of 22 students from the MD/PhD track, 18 students from the Journey into Biomedical Sciences track, 20 students from the Clinical Research/Epidemiology track, and 30 students from the Free Research track. From the other seven students, data regarding the track in which they participated was missing. The evaluation showed that 92.9% of the students were satisfied with the way the goals and opportunities of the programme were communicated. Overall, the evaluation indicated that the Honours programme offered by the LUMC is well appreciated by the participating medical students because it allows flexible implementation of the offered tracks and the possibility to propose alternative plans. The four tracks of the programme differ regarding their provided structure, therefore, the Honours programme as a whole may appeal to different types of students. A tailor made programme that suits students' individual needs and aspirations may be the key to success. We believe this contributes to the large amount of students participating every year. Moreover, most students who follow the LUMC Honours programme would recommend the programme to their fellow students.

Additionally, students who recently started the Honours programme were interviewed (n = 6). The students were approached during an Honours meeting and asked if they wanted to participate in orientating interviews. Participation was voluntary and interviews were conducted by the first author. The aim of the interviews was to provide insights into reasons students have to participate in the Honours programme. Curiosity in combination with a need for extra challenge seemed to be the most important reason to participate in the programme, as one student said: *"Challenge is the biggest reason and also, I want to discover new things. I want to understand why something works and not only that it works. That is something I miss in my study".* Another motive is that students want to learn more about doing research because of their interest in a research oriented career, one student stated: *"I really want to be a researcher. So the sooner [to start with doing research] the better".* Students also discussed the benefits of doing extracurricular research for possible future choices. One student mentioned research being *"very good for your resume"* and another student said *"if you want to be a specialist, it is self-evident to follow a PhD first. I don't know what kind of specialist I want to be, if I want to specialize at all, but I want to keep my options open. So it seems good that when I do know what I would like to do, I have extra possibilities to do it. That is why it seems good to become familiar with research and that is why I chose the Honours programme as extra activity".* Finally, students mentioned that participating in the Honours programme was a *"perfect way to build a network".*

Conclusion

An extracurricular Honours programme, aimed at directing more students towards a scientific career as physician-scientists, appears to be an effective tool to actively engage undergraduate students in research. By offering the programme to more students than only the obviously highly talented ones, and by providing different tracks of interest, the programme clearly reaches more students. The long term effects of this programme still need to be evaluated by analysing the actual career choices our students make, number and impact of publications, scientific presentations, and research related advanced degrees like a PhD. However, initial experiences of students seem positive already, as is reflected in both the outcomes of the evaluation and the growing number of students participating in the Honours programme.

References

1. Frank JR, Snell L, Sherbino J, editors. *CanMEDS 2015 Physician Competency Framework*. Ottowa: Royal College of Physicians an Surgeons of Canada; ;2015.
2. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
3. Dekker FW. Achieving research competences through medical education. *Perspectives on Medical Education*. 2013;2(4):178-180.
4. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching*. Dordrecht: Springer Science + Business Media; 2014.
5. de Beaufort AJ, de Goeij AFPM. Academic and scientific education in medical curricula in the Netherlands: a programme director's view. *Perspectives on Medical Education*. 2013;2(4):225-229.
6. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
7. Moraes DW, Jotz M, Menegazzo WR, et al. Interest in research among medical students: Challenges for the undergraduate education. *Revista Da Associacao Medica Brasileira*. 2016;62(7):652-658.
8. Kosik RO, Tran DT, Fan APC, et al. Physician Scientist Training in the United States: A Survey of the Current Literature. *Evaluation & the Health Professions*. 2016;39(1):3-20.
9. Solomon SS, Tom SC, Pichert J, Wasserman D, Powers AC. Impact of medical student research in the development of physician-scientists. *Journal of investigative medicine*. 2003;51(3):149-156.
10. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017.
11. Harding CV, Akabas MH, Andersen OS. History and Outcomes of 50 Years of Physician–Scientist Training in Medical Scientist Training Programs. *Academic Medicine*. 2017;92(10):1390-1398.
12. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017;6(6):366–368.
13. Reinders JJ, Kropmans TJ, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. *Medical Education*. 2005;39(2):237.
14. Goldhamer MEJ, Cohen AP, Bates DW, et al. Protecting an Endangered Species: Training Physicians to Conduct Clinical Research. *Academic Medicine*. 2009;84(4):439-445.
15. van Eyk HJ, Hooiveld MHW, Van Leeuwen TN, et al. Scientific output of Dutch medical students. *Medical Teacher*. 2010;32(3):231-235.
16. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online*. 2013;18.
17. Rosenkranz SK, Wang SY, Hu WD. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15.
18. Nel D, Burman RJ, Hoffman R, Randera-Rees S. The attitudes of medical students to research. *South African Medical Journal*. 2014;104(1):32-36.
19. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.

20. Laskowitz DT, Drucker RP, Parsonnet J, Cross PC, Gesundheit N. Engaging students in dedicated research and scholarship during medical school: the long-term experiences at Duke and Stanford. *Academic Medicine*. 2010;85(3):419-428.
21. Vereijken MWC, van der Rijst RM, van Driel JH, Dekker FW. Student learning outcomes, perceptions and beliefs in the context of strengthening research integration into the first year of medical school. *Advances in health sciences education: theory and practice*. 2018;23(2):371-385.
22. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
23. Ho T, Agarwal A, Khambhati J, Sarfaty S, Hirsch AE. Faculty and Student Evaluations of a Medical Student Summer Research Program: a 15 Year Analysis. *Medical Science Educator*. 2017;27(1):75-82.
24. Janmaat VT, Kortekaas KE, Moerland TM, et al. Tutored Learning: An Effective Way for Students to Benefit Research by Critical Appraisal. *Medical Science Educator*. 2013;2(23):269-277.
25. Vereijken MW, Kruidering-Hall M, de Jong PG, de Beaufort AJ, Dekker FW. Scientific education early in the curriculum using a constructivist approach on learning. *Perspectives on Medical Education*. 2013;2(4):209-215.
26. Achterberg C. What is an honors student? *Journal of the National Collegiate Honors Council-Online Archive*. 2005:170.
27. Rothman KJ. *Epidemiology: an introduction*. Oxford university press; 2012.

9

The importance of motivation in selecting undergraduate medical students for extracurricular research programmes

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Abstract

Introduction: Extracurricular research programmes (ERPs) may contribute to reducing the current shortage in physician-scientists, but usually select students based on grades only. The question arises if students should be selected based on their motivation, regardless of their previous academic performance. Focusing on grades and lacking to take motivation into account when selecting students for ERPs might exclude an important target group when aiming to cultivate future physician-scientists. Therefore, this study compared ERP students with lower and higher previous academic performance on subsequent academic performance, ERP performance, and motivational factors.

Methods: Prospective cohort study with undergraduate medical students who filled in a yearly questionnaire on motivational factors. Two student groups participating in an ERP were compared: students with first-year grade point average (GPA) ≥7 versus <7 on a 10-point grading scale. Linear and logistic regressions analyses were used to compare groups on subsequent academic performance (i.e. third-year GPA, in-time bachelor completion), ERP performance (i.e. drop-out, number of credits), and motivational factors (i.e. intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, curiosity), while adjusting for gender and motivational factors at baseline.

Results: The <7 group had significantly lower third-year GPA, and significantly higher odds for ERP drop-out than the ≥7 group. However, there was no significant between-group difference on in-time bachelor completion and the <7 group was not inferior to the ≥7 group in terms of intrinsic motivation for research, perceptions of research, and curiosity.

Conclusions: Since intrinsic motivation for research, perceptions of research, and curiosity are prerequisites of future research involvement, it seems beneficial to focus on motivation when selecting students for ERPS, allowing students with lower current academic performance to participate in ERPs as well.

Introduction

Serious concerns have been raised regarding the future of academic medicine in the past decades, as a result of a continued physician-scientist shortage.[1-4] Physician-scientists are healthcare professionals who devote a substantial amount of their time to both clinical care and research.[5,6] Thereby, physician-scientists are pivotal to bridge the gap between science and practice: they play an important role in both identifying relevant clinical problems to be translated into research (i.e. bedside-to-bench) as well as translating research outcomes into clinical practice (i.e. bench-to-bedside).[6-10] However, the decline in physician-scientists as first described in 1979 still persists and the current physician-scientist workforce is aging.[1-4,10,11]

A possible solution to retain the physician-scientist workforce could be to engage medical students in research early on in medical training.[1,12-14] Engagement of undergraduate students in research could help to 1) promote awareness and critical appraisal of research among students, 2) motivate students to conduct research, 3) identify possibilities for a research career among students, and 4) recognize research talent by educators, researchers or physicians.[9,15-17]

The importance of research during medical training has been underlined in many medical educational frameworks and accrediting bodies.[18-20] Furthermore, the Boyer Commission presented a report with ten recommendations for reconstructing undergraduate medical education, with the first recommendation urging to make research-based learning the standard. As a result of the importance given to research by educational frameworks and accrediting bodies, and in line with the Boyer Commission's call to promote engagement of undergraduate students in research, many medical schools started intra- and/or extracurricular initiatives to engage students in research.[14,21,22] As involvement in research during medical training is associated with involvement in research during future professional practice, stimulating undergraduate students to engage in research during early phases of medical training could well be seen as a first step in the physician-scientist pipeline.[12,23]

In order to promote in-depth research involvement, an academic mindset, and by extension cultivate future physician-scientists, many medical schools implemented extracurricular research programmes (ERPs).[1,22] Such programmes occur under different names and diverse formats, e.g. MD/PhD programmes, capstone programmes, summer research programmes, and Honours programmes.[13,22,24,25] Some previous studies into the effects of ERPs showed that they enhanced students' interest in and appreciation of research, increased research skills and productivity, and promoted continued involvement in research.[1,26-29]

Selection procedures of ERPs, especially Honours programmes, usually focus on grades as a means to select 'excellent' students.[30-33] According to Ericsson (1993), one way to define excellence is by current performance; perceiving students who have the highest grades as the most excellent students.[34,35] When defining excellence in this manner, selection of students for ERPs based on grades seems logical.

However, although high grades may be predictive for knowledge recall, they lack predictive validity for knowledge application and higher order cognitive skills.[36] Conducting research can be seen as a higher order cognitive skill, which implies that selecting students for ERPs should go beyond just grades. This may certainly be the case in medical Bachelor degree programmes, in which most of the grades are based on exams that focus mainly on knowledge recall. Moreover, the goals of the specific ERPs should be taken into account as well. If the pre-eminent goal of ERPs is to develop an academic mindset and cultivate future physician-scientists, it seems questionable to focus solely on grades. Additionally, it is important to keep in mind that grades do not necessarily reflect all the competencies that are valued in the job market. This might be especially the case for healthcare professionals who must be able to take on different roles (e.g. communicator, collaborator, health advocate, scholar).[19]

Indeed, an alternative perspective on excellence defines excellent students in terms of *potential* performance, emphasizing the equal importance of motivation next to above-average intellectual ability.[37] This perspective, focusing on motivation as a parameter for excellence as well, might better align with the goal of ERPs to promote research involvement, an academic mindset or even cultivate future physician-scientists.

Perceiving students with the highest grades as the most excellent students, without taking motivation into account when selecting students for ERPs that have the goal to cultivate future physician-scientists, might exclude a very important target group of students that are motivated for research and willing to pursue a research-oriented career. In fact, according to Weaver and colleagues, the strongest predictor for a physician-scientist career is indeed an existing passion for research.[12] Previous research also showed that, in line with the Self-Determination Theory, intrinsic motivation for research is related to (further) research involvement in medical school, which in turn is related to research involvement in future professional practice.[23,38] In addition, in line with the Social Cognitive Theory, research self-efficacy is believed to be related to research motivation and the tendency to conduct research.[39] Furthermore, according to the Theory of Planned Behaviour, perceptions are related to intentions, which in turn are related to the desired behaviour.[40] Lastly, curiosity is identified as an important antecedent for conducting research.[23] In sum, as the main goal of many ERPs is to foster future physician-scientists, intrinsic motivation for research, research self-efficacy beliefs, positive perceptions of research, and curiosity might be valuable objectives to pursue and promote among ERP students.

The question then arises whether so much emphasis should be placed on grades when selecting students for ERPs. Students with lower current academic performance might become equally motivated for research as a result of participating within the ERP, thereby contributing to the pool of future physician-scientists. In other words, the question arises if emphasis should shift from grades towards motivation when selecting for ERPs aiming to cultivate future physician-scientists. Without taking motivation into account when selecting students for ERPs, an important target group might be excluded. This could have practical implications for the selection of students for certain ERPs.

Therefore, the aim of this study was to investigate if two groups of students in an ERP (students with higher versus lower previous academic performance) differ in subsequent academic performance (i.e. third-year GPA, in-time bachelor completion), ERP performance (i.e. drop-out, number of credits), and motivational factors (i.e. intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, curiosity), by using a prospective, longitudinal approach with a baseline measure. First, we hypothesised that the higher previous performance group will outperform the lower previous performance group on subsequent academic and ERP performance. Second, we hypothesised that the higher previous performance group will not outperform the lower previous performance group on motivational factors because academic skills do not by definition affect motivation for research and students with lower grades may still have a passion for research.

Methods

Context

Within the Netherlands, eight universities provide medical education in line with the Dutch National Blueprint for Medical Education, which is based on the CanMEDS.[18,19] Medical education in all universities is comparable in structure consisting of a six-year undergraduate educational programme, with a three-year programme leading to a Bachelor degree and a subsequent three-year programme leading to a Master degree in Medicine. Leiden University Medical Center (LUMC) is one of eight medical faculties in the Netherlands. Medical students' academic performances are assessed with grades on a 10-point grading scale. Within this grading system, 10 is the highest achievable grade and 6 is the pass grade. GPA is the average of all obtained grades, also reported on a scale of 1 to 10. Grades are not only used to assess students' academic performance, but in general also play a role in selecting students for ERPs. In most ERPs, a GPA of 7 is the threshold for entering. However, on top of the core curriculum, LUMC offers students the possibility to participate in a voluntary ERP (i.e. research-based Honours programme), without requiring a GPA of 7 or higher as the threshold for entering. Every medical student can apply, as in the past years selection was mainly based on self-selection without very strict institutional criteria. Consequently, the way our programme is implemented offers a unique opportunity to compare students with a GPA below and above 7. Students do, however, need to graduate in time and with a GPA of 7 or higher within the regular educational programme in order to receive a certificate from the ERP. Within this programme, LUMC aims to foster research talent and students are provided with the opportunity to conduct research individually. The programme starts in the second year of medical school and lasts two years. On average, about 50-60 motivated students participate in the programme each year, which represents 15-20% of the whole second year cohort of medical students. Furthermore, students need to obtain 30 credits (ECTS, i.e. European Credit Transfer and Accumulation System, which means that students have to invest 28 hours of active study per credit).[25]

Design and participants

This prospective cohort study is part of a longitudinal study in which one cohort of medical undergraduates is followed through medical education. All students starting medical school in 2016 were asked to participate in the longitudinal study, and requested to fill in one questionnaire each year (e.g. November 2016, January

2018, December 2018). Furthermore, grades and ERP performance characteristics were obtained. In the present study, all students participating in the ERP of the LUMC were included.

Materials and definitions

To investigate the effect of student group on *academic performance*, GPA of the third year of medical education (GPA3) and time to degree were drawn from university files. To investigate the effect on *ERP performance*, drop-out from and number of ECTS in the programme were drawn from university files as well. Lastly, to examine the effect of student group on *motivational factors*, questionnaire data were used.[38] The questionnaire was based on existing and validated scales, which were adjusted to the medical education setting with a focus on conducting research. Students were asked to score items on a 7-point Likert scale ranging from *1 – 'totally disagree'* to *7 – 'totally agree'*.

Intrinsic motivation for research was defined as students being motivated to conduct research out of their own interest. The scale consisted of five items (e.g. 'doing research is fun') based on the Interest/Enjoyment Scale of the Self-Determination Questionnaires.[41,42] Research self-efficacy was defined as students' beliefs about their ability to conduct research. The scale consisted of three items (e.g. 'I feel I am competent enough to do research') and was self-developed, but inspired by the Dutch General Self-Efficacy Scale and the Academic Efficacy Scale.[43,44] Perceptions of research were defined as students' beliefs about the value of research. The scale consisted of five items (e.g. 'It is important for medical professionals to have scientific skills') of the Student Perception of Research Integration Questionnaire.[45] Lastly, curiosity was measured with ten items (e.g. 'I enjoy investigating new ideas') of the Epistemic Curiosity Scale.[46]

Procedure

After adjustment of the existing scales, the questionnaire was translated from English to Dutch by using the forward and backward translation procedure. In a pilot study, we pretested the questionnaire amongst ten undergraduate medical students in their second year of medical education, after which two minor adjustment to two items were made. All first-year medical students starting medical training in 2016 were approached by the first author during a workgroup session (T1 baseline - November

2016). The same students were approached again in the first semester of their second (T2 - January 2018) and third year (T3 - December 2018) of medical school.

Students were informed about the goals and voluntary nature of participating in this study. Additionally, it was explained to students that all data would be used for research purposes and would be processed anonymously. Furthermore, written consent was asked to connect data of all questionnaires and to connect questionnaire data to prior and subsequent academic and ERP performance. This study was approved by the ethical review board of the Netherlands Association of Medical Education: reference number 952.

Analyses

We used descriptive statistics to report demographics of the participants. We calculated Cronbach's alpha to estimate the reliability of the scales. Mean scores were calculated for the motivational factors. Students in the ERP were divided in two groups based on GPA of the first year of undergraduate medical education (GPA1) prior to the start of the ERP: GPA1 ≥7 versus GPA1 <7. We used independent t-tests to examine if the two groups differed on the motivational factors at the start of medical training (i.e. T1 – baseline scores). Both univariate as well as multivariate logistic and linear regression analyses were used to compare the two groups of students on academic performance, ERP performance, and motivational outcomes, adjusting for baseline motivation and gender.

To test our first hypothesis that the ≥7 group outperforms the <7 group on subsequent academic and ERP performance, we assessed whether the difference in performance was significantly different from zero by looking at 95% confidence intervals. However, to test our second hypothesis that the ≥7 group does not outperform the <7 group on motivational outcomes, we need a different approach. More specifically, we sought to demonstrate that there was no difference in motivational outcomes between the two groups. However, testing whether a difference in motivational outcomes is significantly different from zero will not help in demonstrating there is in fact no difference, as lack of statistical significance would not prove *absence of difference* between the two groups. Instead, we assessed whether the difference was not more than a certain pre-set margin. In this so-called non-inferiority approach, the non-inferiority margin is the maximum difference below which we consider the groups to be not meaningfully different.[47] We elaborated on the non-inferiority margin and reached consensus on a non-inferiority margin of 0.5 on the motivational scales. Hence, we tested if the groups differ by less than 0.5 on motivational outcomes, and thus that the difference is significantly smaller than 0.5, by assessing whether 0.5 is outside the 95% confidence interval. If so, we can conclude that the <7 group and the ≥7 group do not meaningfully differ in motivational outcomes, and the <7 group at most performs only marginally worse. We analysed all data using IBM SPSS Statistics version 23.

Results

Within this cohort existing out of 315 students, a total of 59 students participated in the ERP. All 59 students consented to participate in the current study, of whom 13 (22%) were male and 46 (88%) were female students. This male/female distribution is comparable to the distribution within the whole cohort of medical students. The 59 students were divided in 29 students in the ≥7 group (49.2%) and 30 students (50.8%) in the <7 group. Baseline scores of the two groups on GPA1, intrinsic motivation for research, research self-efficacy, perceptions of research, and curiosity can be found in Table 1. All students are included in the analyses of academic and ERP performance. In total, 57 out of 59 ERP students participated in the baseline survey (96.6%), and 54 out of 59 students participated in the third-year survey (91.5%) addressing the motivational factors. Cronbach's alpha was calculated for the scales of the questionnaire and ranged from .81 to .88 at baseline T1 (November 2016, first year of medical school) and from .80 to .89 at T3 (December 2018, third year of medical school). At baseline, the two groups of students did not differ significantly on the motivational factors. GPA3, in-time bachelor completion, drop-out rates, number of credits within the programme, and T3 motivational scores are reported in Table 2.

Academic performance

An effect of student group on GPA3 was found, with students in the <7 group performing significantly lower in the third year of medical education (β = -.48, 95%CI = -.66 - -.29). This effect remained after adjusting for gender and the motivational factors at baseline (β = -.46, 95%CI = -.67- -.25). However, there was no effect on in-time bachelor completion (crude OR = .80, 95% CI = .19 – 3.33; adjusted OR = .83, 95%CI = .17 – 4.00).

Table 1. Baseline characteristics divided by ≥7 (n = 29) and <7 (n = 30) student group

	≥7 student group	*<7 student group*
Gender		
Male	6 (20.7%)	7 (23.3%)
Female	23 (79.3%)	23 (76.7%)
GPA year 1		
n	29	30
M (SD)	7.64 (.44)	6.73 (.15)
Min-Max	7.02-8.92	6.41-6.96
Intrinsic motivation T1		
n	28	29
M (SD)	5.98 (.64)	5.72 (.71)
Min-Max	4.8-7.0	4.2-6.8
Research self-efficacy T1		
n	28	29
M (SD)	5.13 (.98)	5.14 (.96)
Min-Max	3.0-7.0	3.0-6.7
Perceptions of research T1		
n	28	29
M (SD)	5.92 (.73)	5.81 (.84)
Min-Max	3.8-7.0	2.8-6.8
Curiosity T1		
n	28	29
M (SD)	5.45 (.65)	5.47 (.73)
Min-Max	4.1-6.6	4.3-6.9

ERP performance

With regard to ERP performance, a significant effect was found from student group on ERP drop-out. The odds for ERP drop-out were significantly higher in the <7 group (OR = 3.82, 95% CI = 1.29 – 11.28), also after adjusting for gender and motivational baseline scores (OR = 4.25, 95% CI = 1.29 – 13.94). Furthermore, a significant effect was found regarding the number of credits in the programme, with students in the <7 group obtaining less credits than students in the ≥7 group (crude β = -11.55, 95%CI = -19.60 - -3.50; adjusted β = -12.52, 95%CI = -20.83 - -4.20).

Table 2. Overview of outcome measures divided by ≥7 (n = 29) and <7 (n = 30) student group

	≥7 student group	*<7 student group*
GPA year 3		
M (SD)	7.62 (.41)	7.14 (.25)
Min-Max	6.77-8.65	6.70-7.75
In-time bachelor completion		
no (%)	4 (13.8%)	5 (16.7%)
yes (%)	25 (86.2%)	25 (83.3%)
ERP drop-out		
no (%)	18 (62.1%)	9 (30%)
yes (%)	11 (37.9%)	21 (70%)
Amount of ECTS		
M (SD)	23.72 (17.39)	12.17 (13.29)
Min-Max	0 – 55	0 - 41
Intrinsic motivation T3		
n	26	28
M (SD)	5.98 (.61)	5.81 (.69)
Min-Max	4.8-7.0	4.0-7.0
Research self-efficacy T3		
n	26	28
M (SD)	5.10 (.98)	4.70 (.81)
Min-Max	3.3-7.0	2.0-6.0
Perceptions of research T3		
n	26	28
M (SD)	5.45 (.79)	5.75 (.87)
Min-Max	4.0-7.0	3.8-7.0
Curiosity T3		
n	26	28
M (SD)	5.29 (.64)	5.49 (.69)
Min-Max	3.8-6.7	4.1-6.9

9

Motivational factors

With regard to the motivational factors, the non-inferiority margin was set at 0.5 points. Our findings showed that, after adjusting for gender and the motivational factors at baseline, -0.5 was not in the 95% confidence interval for intrinsic motivation for research (β = -.13, 95%CI = -.44 - .19), perceptions of research (β = .29, 95%CI = -.16 - .74), and curiosity (β = .12, 95%CI = -.21 - .44). Thus, with 95% confidence, the difference in these motivational factors is smaller than 0.5 and students in the <7 group are not inferior to ≥7 group when it comes to these motivational factors. When looking at research self-efficacy, -0.5 is within the confidence interval (β = -.40, 95%CI = -.89 - .09, p = .11). Therefore, we cannot conclude that the <7 group is not inferior to the ≥7 group. An overview of these findings can be found in Table 3.

Table 3. Regression model of the effect of type of student on the motivational factors in the third year of medical education

	Crude β (95%CI)	Adjusted for gender and motivational baseline scores β (95%CI)
Intrinsic motivation	-.16 (-.52 - .19)	-.13 (-.44 - .19)
Research self-efficacy	-.40 (-.89 - .09)	-.40 (-.89 - .09)
Perceptions of research	.30 (-.16 - .75)	.29 (-.16 - .74)
Curiosity	.20 (-.16 - .56)	.12 (-.21 - .44)

*reference: ≥7 group

Discussion

Within this study, we compared two groups of students on three outcome levels: academic performance, ERP performance, and motivational factors. We hypothesized that the ≥7 group would outperform the <7 group on academic and ERP performance, but not on motivational factors. In line with our first hypothesis, the <7 group had lower academic performance (GPA3), significantly higher odds for ERP drop-out and less credits within the ERP compared to the ≥7 group. Confirming our second hypothesis, the <7 group is not inferior to the ≥7 group on intrinsic motivation for research, perceptions of research, and curiosity in the third year of medical education. In other words, intrinsic motivation for research, perceptions of research, and curiosity in the third year of medical education did not differ meaningfully between both groups. The only contradiction to our hypotheses was found on in-time bachelor completion, as the two groups of students did not significantly differ in obtaining their bachelor degree in the appointed amount of time.

In line with our hypotheses, the <7 group obtained lower levels in GPA3, but did however not seem to differ in time to obtain their degree. ERPs expose students to additional workload on top of their regular medical training.[33,48] One concern when it comes to including students beyond the 'excellent' and 'high-achieving' student population in certain programmes, is that these students might not be able to combine the additional workload with the regular courses, and that ERP participation will have a negative impact on academic performance in the regular programme. As we did not find a significant difference in in-time bachelor completion, it could be that the <7 group, though on average obtaining 0.5 points lower with regard to GPA3, did not differ from the ≥7 group on in-time bachelor completion. Moreover, the mean difference between the two groups on GPA3 narrowed as compared to GPA in the first year of medical school, as the GPA of the <7 group increased to a larger extent. These findings indicate that ERP participation is not at the expense of the regular programme. ERP participation might even lead to a greater advantage for the <7 group, as participating in the programme may even enhance their GPA in the subsequent years. An explanation for this could be that students in the ERP are surrounded by highly motivated peers.[48] This is in line with the 'reflected glory effect', referring to the tendency individuals have to relate one's self-perceived ability to the success of others.[49] Within this context, students in the <7 group might identify themselves with the selective group of high-achieving and motivated peers, which has a positive impact on their self-perceived ability. This, in turn, is in line with findings by another study showing that improved self-concept is related to increased learning outcomes.[50]

Our findings suggest that the <7 student group obtained significantly less credits within the programme. This is probably associated with the fact that for students in the <7 group the odds for ERP drop-out were about four times as high. It is remarkable that, though comparable in motivation for research, the drop-out in the <7 group is higher as compared to the ≥7 group, possibly implying that motivation does not lead to ERP completion. The question arises if attrition from the ERP results from a lack of ability to conduct research, or that other reasons might lead to the decision to quit the programme among students. Dropping out of the programme might not per definition mean that students are deterred from research. A reason for the higher ERP drop-out rate may be that, although students with GPA <7 are allowed to participate within the programme, a requirement is that students graduate and receive their medical Bachelor's degree with an average grade of 7 or higher to obtain the ERP certificate.[25] Students who already started the programme with lower grades might feel they will not meet this requirement, and could therefore decide to quit the programme in advance. In addition, this rule sends out the implicit message that students scoring below 7 are not the type of students that are supposed to be enrolled within such ERPs.[51] Some students within the regular cohort also voluntarily conduct extracurricular research without following the structured ERP, so it could be that students dropping out from the ERP decide to follow this path as well. Another possible explanation for the higher chance of dropping out in the <7 group may be the 'big fish little pond – effect', which has the opposite effect for other types of students as compared to the reflected glory hypothesis. According to the big fish little pond – effect, students' self-perceived ability is determined by the comparison with peers. Students participating in an ERP compare themselves with the smaller group of participants within the programme, while largely surrounded by high-achieving, 'top of their class' peers. A similar student in the regular programme will compare itself with the bigger pond of students, differing in cognitive ability. As a result of this change in reference, the <7 group within the programme might have lower levels of self-perceived ability because they are surrounded by some 'big fish' (i.e. the high-achieving GPA1 ≥7 students) in their little pond (i.e. smaller group of programme participants).[49,52,53]

Should this higher level of drop-out, then, be a reason to only include 'excellent' students in certain programmes in the future? From an efficiency perspective, one might say that drop-out within a rather costly programme should be avoided. Furthermore, it could be argued that select groups of students receive additional education which needs to be justified, especially because these graduates are more appealing for job recruiters.[52] Lastly, one might wonder if students not completing the ERP will be able to deal with the pressures in future professional practice, for instance combining research and clinical duties. These perspectives might contribute to the idea of solely including high-achieving students in such extracurricular programmes to prevent attrition, aligned with Ericsson's perspective on 'excellence'.

However, when evaluating ERPs, a focus on academic and ERP performance might provide an incomplete image when aiming to deliver professionals who fit the needs of the specific field.[32,52] When looking at the *motivational factors* in the current study, our results are inconclusive with respect to research self-efficacy beliefs in the third year of medical education, although they seem to be somewhat higher in the ≥7 group. A study by Kool and colleagues[54] showed that high-achieving students were more performance oriented, defined as students' pursuit to outperform peers and show their own abilities, which might explain the higher levels of confidence in their own abilities among the students in the ≥7 group. In addition, for some students the big fish little pond – effect might apply here as well. A practical implication derived from these findings might be to support motivated, above-average ability students in ERPs in such ways that their research self-efficacy beliefs are enhanced, as research self-efficacy is related to research motivation and the tendency to conduct research.[39]

More importantly, our study showed that the two groups of students are comparable in intrinsic motivation for research, perceptions of research, and curiosity in the third year of medical education. In line with major theories like Self-Determination Theory, Social Cognitive Theory, and Theory of Planned Behaviour, as well as findings from previous studies, these constructs are related to actual research engagement.[23,38-42]

Thus, despite the higher ERP drop-out rates in the <7 group, the group is not inferior to the ≥7 group on the desired outcomes that are imperative to cultivate future physician-scientists. In addition, one might say these students are supported in their development regardless of whether they eventually finished the ERP. But above all, if the pre-eminent goal of ERPs is to develop future physician-scientists, this goal is not endangered by including students with lower academic performances in their first year of medical training. In fact, these students might well belong in the target group when aiming to cultivate future physician-scientists and selection based solely on grades poses the risk to exclude a motivated group of students from the physician-scientist training pipeline.

To summarize, students in the <7 group quit the ERP more often and have lower GPA in the third year of medical education, but ERP participation may help to enhance student GPA of the first years of undergraduate medical study in the <7 group. More importantly, the <7 group scored comparable to the ≥7 group on intrinsic motivation for research, perceptions of research, and curiosity, which are all motivational factors underlying research involvement in future professional practice. Therefore, when aiming to cultivate future physician-scientists, our findings imply that the perspective on excellence emphasizing *potential performance* and the equal importance of motivation is more aligned with the aims of ERPs. Especially when taking into account that medical students invest a great amount of academic effort before entering medical school and are selected on, among others, cognitive abilities.[55] To conclude, this could mean that, in order to use ERPs as a step in the physician-scientist pipeline, motivation should be given importance in selecting students for ERPs, allowing students with a GPA lower than seven to participate within such programmes as well. This could be established by using a selection model in which GPA is not perceived as a threshold to enter the ERP. Insights in motivation of students willing to self-select within the ERP could be elucidated by, for instance, asking students to write a motivation letter to reflect on their feelings of competence within the regular educational programme (i.e. academic self-efficacy) and their motivation to participate within the specific ERP. Furthermore, it could be valuable to offer students a low-threshold activity in which they can get acquainted with the ERP to substantiate their willingness to participate within the ERP.

Strengths, limitations and future research

First, our study was performed within a single institute. However, our medical curriculum is comparable to other medical curricula as the educational programme is based on the Dutch National Blueprint for Medical Education, which in turn is aligned with, among others, the CanMEDS.[18,19] Additionally, many medical schools worldwide provide undergraduate students with ERPs. Second, the outcome measures of the current study are not long-term measures like, for instance, publication rates. However, previous studies have shown that both research involvement within medical training, as well as the measured motivational factors within this study, are related to long-term scientific involvement.[23,38,56] Valuable for future research might be to include long-term effects with scholarly output (e.g. publications and conference contributions), and a career as a physician-scientist. Third, the groups within our study were relatively small. Therefore, an interesting future research avenue might be to conduct this study within different contexts and, when possible, larger groups. Furthermore, future research could focus on identifying causes of lower credits in the < 7 group as well as investigating if ERP drop-outs perceive this negatively and what is needed to support all different types of students and promote every student to flourish within such ERPs. A qualitative approach could help to provide more in-depth insights into the above mentioned topics. In addition, reasons for drop-out and subsequent intentions to pursue research, or lack thereof, might be valuable to identify.

Conclusion

Two groups of students within an ERP were compared on three outcome levels: academic performance, ERP performance, and motivational factors. The <7 group obtained lower levels of GPA3 and had significantly higher odds for ERP drop-out. On the contrary, the <7 group did not differ from the ≥7 group on in-time bachelor completion, and had comparable levels of intrinsic motivation for research, perceptions of research, and curiosity in the third year of medical education, which are all factors underlying research involvement in future professional practice. Therefore, for ERPs aiming to develop future physician-scientists, a shift from an emphasis solely on grades towards taking motivation into account could be beneficial for the selection for such programmes, allowing students with lower current performance to participate as well.

References

1. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
2. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
3. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation*. 2015;125(10):3742-3747.
4. NIH. Physician-scientist Workforce (PSW). Working Group Report. NIH Web site. http://acd.od.nih.gov/reports/PSW_Report ACD_06042014.pdf. Updated June 1, 2014. Accessed February 3, 2020. 2. NIH. Biomedical Research Workforce. 2014.
5. Sklar DP. We Must Not Let Clinician-Scientists Become an Endangered Species. *Academic Medicine.* 2017;92(10):1359-1361.
6. Weggemans MM, Friesen F, Kluijtmans M, et al. Critical Gaps in Understanding the Clinician-Scientist Workforce: Results of an International Expert Meeting. *Academic Medicine*. 2019;94(10):1448-1454.
7. Woolf SH. The Meaning of Translational Research and Why It Matters. *Jama*. 2008;299(2):211-213.
8. Butler D. Translational research: crossing the valley of death. *Nature*. 2008;453(7197):840-842.
9. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator.* 2011;21:258-260.
10. Salata RA, Geraci MW, Rockey DC, et al. U.S. Physician-Scientist Workforce in the 21st Century: Recommendations to Attract and Sustain the Pipeline. *Academic Medicine*. 2018;93(4):565-573.
11. Wyngaarden JB. The clinical investigator as an endangered species. *The New England journal of medicine*. 1979;301(23):1254-1259.
12. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine.* 2017;65(5):942-948.
13. Green EP, Borkan JM, Pross SH, et al. Encouraging Scholarship: Medical School Programs to Promote Student Inquiry Beyond the Traditional Medical Curriculum. *Academic Medicine*. 2010;85(3):409-418.
14. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online*. 2013;18.
15. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching.* Dordrecht: Springer Science + Business Media; 2014.
16. Graham MJ, Frederick J, Byars-Winston A, Hunter AB, Handelsman J. Increasing Persistence of College Students in STEM. *Science*. 2013;341(6153):1455-1456.
17. Walkington H, Griffin AL, Keys-Mathews L, et al. Embedding Research-Based Learning Early in the Undergraduate Geography Curriculum. *Journal of Geography in Higher Education.* 2011;35(3):315-330.
18. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009.* Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
19. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
20. Swing SR. The ACGME outcome project: retrospective and prospective. *Medical Teacher.* 2007;29(7):648-654.

21. Scager K, Akkerman SF, Pilot A, Wubbels T. Challenging high-ability students. *Studies in Higher Education*. 2014;39(4):659-679.
22. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
23. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one*. 2015;10(6):e0127470.
24. Ho T, Agarwal A, Khambhati J, Sarfaty S, Hirsch AE. Faculty and Student Evaluations of a Medical Student Summer Research Program: a 15 Year Analysis. *Medical Science Educator*. 2017;27(1):75-82.
25. Ommering BWC, van den Elsen PJ, van der Zee J, Jost CR, Dekker FW. Using an Extracurricular Honors Program to Engage Future Physicians Into Scientific Research in Early Stages of Medical Training. *Medical Science Educator*. 2018;28(2):451-455.
26. Burgoyne LN, O'Flynn S, Boylan GB. Undergraduate medical research: the student perspective. *Medical Education Online*. 2010;15(1):5212.
27. Solomon SS, Tom SC, Pichert J, Wasserman D, Powers AC. Impact of medical student research in the development of physician-scientists. *Journal of investigative medicine*. 2003;51(3):149-156.
28. Blazer D, Bradford W, Reilly C. Duke's 3rd year: a 35-year retrospective. *Teaching and Learning in Medicine*. 2001;13(3):192-198.
29. Griffin MF, Hindocha S. Publication practices of medical students at British medical schools: experience, attitudes and barriers to publish. *Medical Teacher*. 2011;33(1):e1-8.
30. Rinn AN, Plucker JA. We recruit them, but then what? The educational and psychological experiences of academically talented undergraduates. *Gifted Child Quarterly*. 2004;48(1):54-67.
31. Kool A. *Excellence in higher education: Students' personal qualities and the effects of undergraduate honours programmes*, Utrecht University; 2016.
32. Scager K, Akkerman SF, Keesen F, Mainhard MT, Pilot A, Wubbels T. Do honors students have more potential for excellence in their professional lives? *Higher Education*. 2012;64(1):19-39.
33. Wolfensberger MVC, van Eijl PW, Pilot A. Honours Programmes as Laboratories of Innovation: A Perspective from the Netherlands. *Journal of the National Collegiate Honors Council* 2004;5(1):115-142.
34. Ericsson KA, Krampe RT, Teschromer C. The Role of Deliberate Practice in the Acquisition of Expert Performance. *Psychological Review*. 1993;100(3):363-406.
35. Ericsson KA, Nandagopal K, Roring RW. Giftedness Viewed From the Expert-Performance Perspective. *Journal for the Education of the Gifted*. 2005;28(3-4):287-311.
36. Steenman SC, Bakker WE, van Tartwijk JWF. Predicting different grades in different ways for selective admission: disentangling the first-year grade point average. *Studies in Higher Education*. 2016;41(8):1408-1423.
37. Renzulli JS. What Makes Giftedness - Reexamining a Definition. *Phi Delta Kappan*. 1978;60(3):180-&.
38. Ommering BWC, van Blankenstein FM, Wijnen-Meijer M, van Diepen M, Dekker FW. Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. *BMJ open*. 2019;9(7):e028034.
39. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
40. Ajzen I. The theory of planned behavior. *Organizational behavior and human decision processes*. 1991;50(2):179-211.

41. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist.* 2000;55(1):68-78.
42. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* Guilford Publications; 2017.
43. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L, Freeman KE. *Manual for the Patterns of Adaptive Learning Scales (PALS).* Ann Arbor: University of Michigan2000.
44. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in health psychology: A user's portfolio. Causal and control beliefs.* Windsor, UK: NFER-NELSON; 1995:35-37.
45. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International.* 2016:1-8.
46. Litman JA. Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences.* 2008;44(7):1585-1595.
47. Soonawala D, Dekkers OM. 'Non-inferiority' trials. Tips for the critical reader. *Nederlands Tijdschrift voor Geneeskunde.* 2012;156(19):A4665.
48. Kool A, Mainhard MT, Jaarsma ADC, Brekelmans M, van Beukelen P. Academic success and early career outcomes: Can honors alumni be distinguished from non-honors alumni? *High Ability Studies.* 2016;27(2):179-192.
49. Marsh HW, Kong CK, Hau KT. Longitudinal multilevel models of the big-fish-little-pond effect on academic self-concept: Counterbalancing contrast and reflected-glory effects in Hong Kong schools. *Journal of Personalitu and Social Psychology.* 2000;78(2):337-349.
50. Marsh HW, Trautwein U, Ludtke O, Koller O, Baumert J. Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Developent.* 2005;76(2):397-416.
51. Verhoeven M, Poorthuis AMG, Volman M. The Role of School in Adolescents' Identity Development. A Literature Review. *Educational Psychology Review.* 2019;31(1):35-63.
52. Kool A, Mainhard T, Jaarsma D, van Beukelen P, Brekelmans M. Effects of honours programme participation in higher education: a propensity score matching approach. *Higher Education Research & Development.* 2017;36(6):1222-1236.
53. Rinn AN. Effects of programmatic selectivity on the academic achievement, academic self-concepts, and aspirations of gifted college students. *Gifted Child Quarterly.* 2007;51(3):232-245.
54. Kool A, Mainhard T, Brekelmans M, van Beukelen P, Jaarsma D. Goal orientations of health profession students throughout the undergraduate program: a multilevel study. *BMC Medical Education.* 2016;16.
55. Ten Cate O. Medical education in the Netherlands. *Medical Teacher.* 2007;29(8):752-757.
56. Waaijer CJF, Ommering BWC, van der Wurff LJ, van Leeuwen TN, Dekker FW, Education NSIGoS. Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. *Perspectives on Medical Education.* 2019;8(4):223-229.

10

First steps in the physician-scientist pipeline: a longitudinal study to examine effects of an undergraduate extracurricular research programme

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Submitted

Abstract

Purpose: Medicine is facing a physician-scientist shortage. By offering extracurricular research programmes (ERPs), the physician-scientist training pipeline could already start in undergraduate phases of medical training. However, previous studies into the effects of ERPs are mainly retrospective and lack baseline measurements and control groups. Therefore, the authors conducted a prospective cohort study with baseline measurement and comparable control group to examine the effects of an ERP on academic achievement and motivational factors.

Method: One cohort of 315 medical undergraduates was followed and surveyed yearly. To examine the effects of the ERP on academic achievement after two years (i.e. in-time bachelor completion, bachelor GPA) and motivational factors after 18 months (i.e. intrinsic motivation for research, research self-efficacy, perceptions of research, curiosity), the authors used regression analyses to compare ERP students (n=56) to students showing ERP-interest only (n=38), adjusted for relevant baseline scores.

Results: ERP participation is related to a higher odds of obtaining a bachelor degree in the appointed amount of time. Furthermore, starting the ERP resulted in higher levels of intrinsic motivation for research, also after adjusting for gender, age, first-year GPA, and motivational baseline scores. No effect was found on research self-efficacy beliefs, perceptions of research, and curiosity.

Conclusions: Previous research suggested that intrinsic motivation is related to short- and long-term research engagement. As our findings indicate that starting the ERP is related to increased levels of intrinsic motivation for research, ERPs for undergraduates could be seen as an important first step in the physician-scientist pipeline.

Introduction

The field of medicine is dynamic with many remaining ‘unknowns’. In order to unravel the unknown and make advancements within the medical domain, research is key. However, to actually benefit patient care, research should be connected to clinical practice. That is, relevant questions and problems originating from daily clinical practice should be identified and translated into research designs (i.e. connecting bedside to bench) and research outcomes should be translated into daily practice (i.e. connecting bench to bedside). Within this process of translational research, physician-scientists play a crucial role.[1-4] Physician-scientists are healthcare professionals investing a solid amount of their time in both research and clinical duties, and are therefore in the unique position to connect bedside to bench and vice versa.[4,5]

Unfortunately, many concerns have been raised regarding the future of the physician-scientist workforce. As a result of the rising age of the current workforce, attrition from the physician-scientist training pipeline, and a decreasing interest to even pursue this pipeline or a scientific career, medicine is currently facing a physician-scientist shortage.[6-9]

A possible solution to foster the physician-scientist workforce is to engage medical students in research in early phases of medical school. Research engagement of medical students is related to research involvement further in medical training and in future professional practice.[10,11]As a result of engaging in research during medical training, students become aware of and motivated for research, possibilities for a research career are identified, and research talent is recognized by medical professionals.[12] In this way, the physician-scientist training pipeline could already start in undergraduate and pre-clinical phases of medical training. To this end, many medical schools have created scholarly programmes, both intra- and extracurricular.[6,8,13] Although extracurricular research programmes occur under diverse names, e.g. scholarly concentration programmes, capstone programmes, summer schools, and Honours programmes, they do share the common goal to engage students in research and cultivate future physician-scientists.

Within the past decades, many research initiatives emerged aiming to map the effects of extracurricular research programmes. For instance, Wolfson et al. (2017) showed that both satisfaction within a scholarly concentration programme and publication in scientific journals as a result of programme participation were related to an enhanced career-long research interest.[6]

A retrospective study by Radville et al. (2019) suggested that graduates who participated in a scholarly concentration programme are more likely to stay scientifically active, as they published more after graduating and more frequently took on an academic health centre job.[14] A recent study by DiBiase et al. (2020) also showed that participation in a scholarly concentration programme is related to increased levels of research self-efficacy, which in turn is related to an enhanced intention to pursue scientific work.[15]

However, within a systematic review it was concluded that most studies into extracurricular research programmes have a retrospective design and evidence for the effect of such programmes resulting from rigorous study designs is lacking.[16] After using the Medical Education Research Study Quality Instrument, the authors concluded that the included studies scored low on study design and validity and called for studies with more rigorous study designs.[16] More specifically, very few studies have investigated the effects of extracurricular research programmes on both academic achievement and motivational factors using a longitudinal design.[17] As grades do not by definition reflect all valued skills of future physicians, it seems beneficial to focus on more than just academic performance as an outcome measure. In addition, students choosing to participate in extracurricular research programmes are believed to differ from students not following this path. Therefore, a sound baseline measure is needed for which a prospective study seems to be a good approach. Lastly, a comparable control group of students who are not participating in the extracurricular research programme is absent in most studies as well. In these cases, the question arises if students would have developed in similar ways within the regular educational programme.[8,16,17]

The current study therefore combines a prospective, longitudinal study design with a sound baseline measure and comparable control group to answer the following research question: 'What is the effect of an extracurricular research programme on academic achievement, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity'. Although with 18 months follow-up these are relatively short-term measures of research engagement, existing theories and previous studies indicate that these constructs are related to long-term research engagement and scholarly output.[10,11,18-21] Furthermore, keeping in mind that grades do not necessarily align with all valued skills as a future physician or physician-scientist, we specifically focused on more than just academic achievement. As the pre-eminent goal of extracurricular research programmes is to cultivate future physician-scientists, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity may be seen as key outcome objectives, especially as they are related to future research involvement.[10,11,18-21]

Methods

Context

Leiden University Medical Center (LUMC) is one of eight universities within the Netherlands offering medical education, in line with the Dutch National Blueprint for Medical Education that is based on the CanMEDS.[22,23] Consequently, the structure of medical education is comparable in all universities with a six-year undergraduate educational programme. In addition to the core curriculum, LUMC implemented an extracurricular research programme (i.e. research-based Honours programme) aiming to foster research talent and cultivate future physician-scientists. The programme, starting in the second year of undergraduate medical education, provides students with opportunities to conduct research individually. Programme duration is two years and selection is mainly based on self-selection without very strict institutional criteria. Thus, every student can apply. As a result, approximately 50-60 motivated students start in the programme each year, representing 15-20% of the whole second year cohort of medical students. To get a certificate for this programme, students need to obtain 30 extra credits (ECTS, i.e. European Credit Transfer and Accumulation System, which means that students have to invest 30 x 28 hours of active study). At the same time, they have to obtain 180 regular ECTS for their three-year Bachelor programme with a grade point average (GPA) of at least 7 on a 10-point grading scale.[24]

Design and participants

Within a longitudinal, prospective study design, one complete cohort of medical undergraduates was followed for three years. Every student starting medical school at the LUMC in 2016 was asked to participate and data was gathered longitudinally by surveying participants each year (i.e. November 2016, January 2018 and December 2018). Ideally, one would aspire a randomized controlled trial (RCT) in order to examine the effects of the extracurricular research programme, dividing students who expressed interest in the programme in a participating and a non-participating group at random. However, as randomization is not possible here, we tried to mimic an RCT by comparing students starting the extracurricular research programme to students that have showed interest in the extracurricular research programme, but eventually decided not to participate. Furthermore, we adjusted for potentially relevant baseline differences to make the groups as comparable as possible.

Materials and definitions

The effects of the extracurricular research programme were examined by comparing the two groups of students on academic achievement two years later and motivational factors 18 months later, while adjusting for relevant baseline scores. Motivational factors consisted of intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity.

Academic achievement was operationalized as students' in-time bachelor completion and bachelor GPA, which were both drawn from university files. For the motivational outcome measures, questionnaire data were used.[10] Existing and validated scales were used to compose the questionnaire, though adjusted to the medical education setting and focusing on conducting research (Appendix C). Students scored the items on a 7-point Likert scale ranging from 1 – 'totally disagree' to 7 – 'totally agree'. *Intrinsic motivation for research* was defined as motivation to conduct research out of pure enjoyment or interest. The scale consisted of five items (e.g. 'doing research is fun'), derived from the Interest/Enjoyment Scale of the Self-Determination Questionnaires.[25] *Research self-efficacy* was defined as students' beliefs about their own abilities to conduct research. This self-developed scale consisted of three items (e.g. 'I feel I am competent enough to do research') and was inspired by the Dutch General Self-Efficacy Scale and the Academic Efficacy Scale.[26,27] *Perceptions of research* was defined as students' beliefs about the value of research. The scale consisted of five items (e.g. 'It is important for medical professionals to have scientific skills'), derived from the Student Perception of Research Integration Questionnaire.[28] *Curiosity* was defined as students' desire for knowledge, promoting learning of new ideas and solving intellectual problems. The scale consisted of ten items (e.g. 'I enjoy investigating new ideas') of the Epistemic Curiosity Scale.[29]

Procedure

The existing scales were adjusted to fit our setting, after which we used the forward and backward translation procedure to translate the questionnaire from English to Dutch. The questionnaire was pretested amongst ten medical students in their second year of undergraduate medical education, after which two minor adjustments were made to two items. For the actual longitudinal study, every student entering medical education in 2016 was approached by a member of the research team during a mandatory workgroup session in one of the first courses of the educational programme (baseline T1 – November 2016). These students were surveyed again in the first semester of their second (T2 – January 2018) and third year (T3 – December 2018) of undergraduate medical education. An overview of the timeline is illustrated in Figure 1. The goals and voluntary nature of participation in this study were communicated to students and it was explained that all data would be processed anonymously and used for research purposes only. Students filled in an informed consent form, approving to connect data of the questionnaires (T1, T2, T3) and the academic achievement components. The study was approved by the ethical review board of the Netherlands Association of Medical Education: reference number 952.

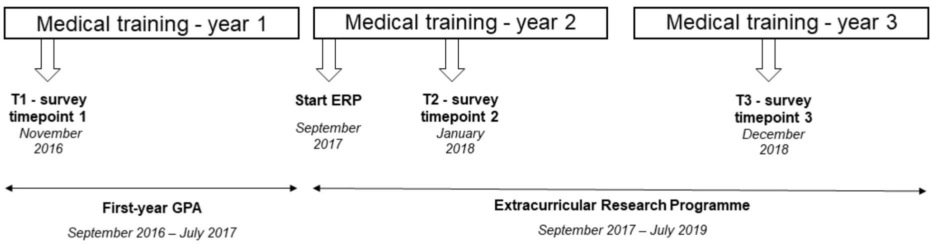

Figure 1. Timeline illustrating ERP start, ERP duration, and survey measurements

Analyses

Descriptive statistics were used to report participants' demographics and Cronbach's alpha was calculated to estimate the reliability of the questionnaire scales. Mean scores were calculated for the motivational factors. Missing data was handled by using multiple imputation.[30] Univariate and multivariate logistic and linear regressions were used to compare students within the programme to the control group outside of the programme on academic achievement, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity. Within the multivariate regressions we adjusted for potential confounding factors: gender, age, T1 baseline scores of all motivational outcome measures, and first-year GPA (i.e. covering the period before starting the extracurricular research programme). Results are presented with 95% confidence intervals. We analysed all data using IBM SPSS Statistics version 23.

Results

Out of in total 315 medical students, 94 students were included within the current study, of whom 56 started in the extracurricular research programme (59.6%). The remaining 38 students (40.4%) showed interest in the extracurricular research programme without self-selecting themselves and actually participating, thus serving as the comparable control group within our study. Of the 56 students starting the programme, 43 students were female (76.8%) and 13 students were male (23.2%) with a mean age of 18.5 (SD = .91) years. The control group comprised of 30 female (78.9%) and 8 male students (21.1%) with a mean age of 18.6 (SD = 1.28) years. Baseline scores of both groups on first-year GPA and the motivational factors can be found in Table 1. Cronbach's alpha of the scales ranged from .78 to .86 at T1 baseline (first year of medical training – November 2016), .79 to .86 at T2 (second year of medical training – January 2018), and .82 to .89 at T3 (third year of medical training – December 2018). In-time bachelor completion, third-year GPA, and T3 scores on intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity are reported in Table 2.

Academic achievement

A crude effect of starting the extracurricular research programme on in-time bachelor completion was found, showing that students starting the programme had higher odds of obtaining their bachelor degree in time (OR = 3.64, 95% CI = 1.29 – 10.27), also after adjusting for gender, age, first-year GPA, and all T1 baseline scores (OR = 2.95, 95% CI = .826 – 10.52). Participating in the extracurricular research programme, on its own, had an effect on students' bachelor GPA (β = .299, 95% CI = .097 – .500). After adjusting for gender, age, first-year GPA, and all T1 baseline scores the effect disappeared (β = -.026, 95% CI = -.160 - .108).

Table 1. Baseline characteristics divided by students entering the extracurricular research programme (ERP) and students showing interest without entering the ERP (n = 94)

	Non ERP *n = 38*	*ERP* *n = 56*
Gender		
Male	8 (21.1%)	13 (23.2%)
Female	30 (78.9%)	43 (76.8%)
Age		
M (SD)	18.63 (1.28)	18.45 (.91)
Min-Max	16-23	17-21
First-year GPA		
n	38	56
M (SD)	6.76 (.45)	7.18 (.55)
Min-Max	6.0-8.1	6.4-8.9
Intrinsic motivation T1		
n	38	56
M (SD)	5.67 (.56)	5.84 (.69)
Min-Max	4.8-7.0	4.2-7.0
Research self-efficacy T1		
n	37	56
M (SD)	5.05 (.96)	5.13 (.97)
Min-Max	3.0-6.7	3.0-7.0
Perceptions of research T1		
n	38	56
M (SD)	5.68 (.67)	5.87 (.79)
Min-Max	4.4-7.0	2.8-7.0
Curiosity T1		
n	38	56
M (SD)	5.37 (.66)	5.46 (.69)
Min-Max	4.3-6.8	4.1-6.9

Table 2. Descriptives of outcome measures divided by non-ERP students and ERP students (n = 94 for academic measures and n = 82 for motivational measures)

	Non ERP	*ERP*
In-time bachelor completion		
in time	25 (65.8%)	49 (87.5%)
delay	13 (34.2%)	7 (12.5%)
Bachelor GPA		
n	38	56
M (SD)	6.93 (.47)	7.23 (.50)
Min-Max	6.0 – 8.1	6.3 – 8.9
Intrinsic motivation T3		
n	30	52
M (SD)	5.36 (.78)	5.85 (.62)
Min-Max	2.8 – 6.4	4.0 – 7.0
Research self-efficacy T3		
n	30	52
M (SD)	4.81 (1.16)	4.85 (.90)
Min-Max	1.7 – 7.0	2.0 – 7.0
Perceptions of research T3		
n	30	52
M (SD)	5.41 (.76)	5.58 (.84)
Min-Max	4.0 – 7.0	3.8 – 7.0
Curiosity T3		
n	30	52
M (SD)	5.22 (.71)	5.37 (.66)
Min-Max	4.0 – 6.7	3.8 – 6.9

Motivational factors

There was a positive effect of starting the extracurricular research programme on intrinsic motivation for research in the third year of medical training (β = .462, 95% CI = .113 - .811), also after adjusting for gender, age, all T1 baseline scores, and first-year GPA (β = .334, 95%CI = .042 - .627). Students starting the programme report higher levels of intrinsic motivation for research in their third year of medical training. Starting in an extracurricular research programme did not, however, have an effect on research self-efficacy beliefs, perceptions of research, and curiosity. An overview of these findings can be found in Table 3.

Table 3. Regression model of the effect of starting the extracurricular research programme on the motivational factors in the third year of medical education (T3)

	Crude β (95%CI), p	Adjusted [a] β (95%CI), p
Intrinsic motivation	.462 (.113 - .811), .010	.334 (.042 - .627), .025
Research self-efficacy	.108 (-.417 - .634), .684	.015 (-.439 - .469), .949
Perceptions of research	.208 (-.203 - .619), .320	.080 (-.109 - .269), .673
Curiosity	.136 (-.163 - .436), .372	.113 (-.173 - .400), .449

[a] Adjusted for age, gender, motivational baseline scores (i.e. intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, curiosity), and first-year GPA

Discussion

Within this study, we compared students starting an extracurricular research programme with students that have showed interest in the same extracurricular research programme, but eventually decided not to participate. By using a longitudinal study design with a sound baseline measure and a comparable control group, we aimed to map the effects of an extracurricular research programme. With regard to academic achievement, our findings suggest that starting the extracurricular research programme leads to higher odds of obtaining a bachelor degree in the appointed amount of time. When it comes to the motivational factors included in our study, our findings showed that starting the extracurricular research programme only affected levels of intrinsic motivation for research significantly, as students starting the programme reported higher levels of intrinsic motivation for research in the third year of medical training. No effect was found on research self-efficacy beliefs, perceptions of research, and curiosity.

With regard to academic achievement, our findings suggest that starting an extracurricular research programme increases the odds of obtaining a bachelor degree in time. From a statistical perspective, this effect is borderline non-significant. There is a broad confidence interval, resulting in some uncertainty regarding the exact size of the effect. However, the best estimate is a strong and relevant effect, as the odds ratio of 2.95 suggests that the odds of success (i.e. in-time bachelor completion) is almost three times as high when students start the extracurricular research programme. Starting the programme did not, however, have a beneficial effect on bachelor GPA. As the crude effect on bachelor GPA disappears after adjusting for first-year GPA, it can be assumed that students' first-year GPA is a confounder related to their choice to participate within an extracurricular research programme as well as related to their subsequent bachelor GPA.

More importantly when focusing on the aim of extracurricular research programmes, our findings suggest there was an effect of the extracurricular research programme on levels of intrinsic motivation for research in the third-year of medical training. According to the Self-Determination Theory, intrinsic motivation (i.e. doing an activity out of pure interest or enjoyment) is related to better academic performances and general wellbeing. Furthermore, we already know that intrinsic motivation for research is related to actual involvement in research during medical training[10], which in turn is related to research involvement in future professional practice.[11,31] Moreover, results of a scoping review reveal that it is especially intrinsic motivation among professionals that influences scientific career progression.[32] These theoretical and scientific notions contribute to the perspective that intrinsic motivation for research is a key component in order to foster future physician-scientists.

Interestingly, however, the extracurricular research programme had no effect on the other motivational factors that we measured. Our results suggest that starting the programme does not significantly increase levels of research self-efficacy among students. This contradicts findings from a recent study, showing that participation in a scholarly concentration programme was related to higher levels of research self-efficacy.[15] However, as the scholarly concentration programme in that study was a mandatory part of medical training, a control group consisting of students not following the programme was absent, making it more difficult to attribute the higher levels of self-efficacy to participating in that specific programme. A possible explanation could be that participating students, while receiving in-depth research experiences, become aware that the process of conducting research could be time-consuming and hard, as is also acknowledged by our students already in their first-year of medical training.[18] In turn, this could diminish feelings of success, which according to the Social Cognitive Theory is related to levels of self-efficacy.[20]

Our findings also suggest that there is no effect of the extracurricular research programme on perceptions of research. Perceptions of research are believed to be related to an apparent connection of research to practice,[18] it could be that this connection to clinical practice is lacking for these young students while submerging in the world of research. It could also be that a course in the first-year of medical training in which students actively conduct research individually, as is implemented by Leiden University Medical Center, contributed to a broad perspective on research and already very positive perceptions of research before starting the extracurricular research programme in the second year of medical training.[18]

Our findings are partly in line with a previous study of Kool and colleagues, in which no effect of participation within an extracurricular programme was found on ability, creativity, and motivation. The reason mentioned for the absence of these effects was that their post-measure was six months after starting the extracurricular programme, which might have been too soon to note changes in ability, creativity, and motivation.[17] Our outcome measures were examined 18 months after starting the extracurricular research programme. Although this might have been too short-term to identify increasing levels of research self-efficacy, perceptions of research, and curiosity, we did find a positive effect on intrinsic motivation for research. The extracurricular research programme can thus be viewed as a way to enhance intrinsic motivation for research and subsequently a first step in the physician-scientist pipeline.

Limitations, strengths and future research

This was a single-institute study which might impact generalizability to other contexts. However, as 1) our educational programme is based on the Dutch National Blueprint for Medical Education, which is an adaptation from the CanMEDS and 2) many medical schools offer extracurricular research programmes to undergraduate medical students, we believe our findings might be translated to other educational contexts as well. Our study is one of the first to use a longitudinal, prospective study design with a sound baseline measure and comparable control group to examine both academic and motivational effects as a result of starting an extracurricular research programme. Future research could focus on identifying how levels of research self-efficacy, perceptions, and curiosity could be increased within the programme, using quantitative and qualitative methods to, for instance, uncover the effect of mentorship and success experiences on the abovementioned motivational factors. Furthermore, we established an effect on intrinsic motivation for research 18 months after starting the extracurricular research programme. Although theoretical and scientific notions corroborate the assumption that this will be related to research engagement even further in the physician-scientist pipeline, a relevant future research avenue could be to investigate if the effect persists. Subsequently, evidence-based strategies could then be implemented to enlarge the short- and long-term effects of extracurricular research programme participation aiming to foster future physician-scientists.

Conclusion

Previous research suggested that intrinsic motivation for research is an important incentive for research engagement during medical training and future professional practice. As we have shown now that starting in an extracurricular research programme is related to increased levels of intrinsic motivation for research, such programmes for undergraduates could be seen as a valuable first step in the physician-scientist pipeline.

References

1. Salata RA, Geraci MW, Rockey DC, et al. U.S. Physician-Scientist Workforce in the 21st Century: Recommendations to Attract and Sustain the Pipeline. *Academic Medicine*. 2018;93(4):565-573.
2. Woolf SH. The Meaning of Translational Research and Why It Matters. *Jama*. 2008;299(2):211-213.
3. Butler D. Translational research: crossing the valley of death. *Nature*. 2008;453(7197):840-842.
4. Weggemans MM, Friesen F, Kluijtmans M, et al. Critical Gaps in Understanding the Clinician-Scientist Workforce: Results of an International Expert Meeting. *Academic Medicine*. 2019;94(10):1448-1454.
5. Sklar DP. We Must Not Let Clinician-Scientists Become an Endangered Species. *Academic Medicine*. 2017;92(10):1359-1361.
6. Wolfson RK, Alberson K, McGinty M, Schwanz K, Dickins K, Arora VM. The Impact of a Scholarly Concentration Programme on Student Interest in Career-Long Research: A Longitudinal Study. *Academic Medicine*. 2017;92(8):1196-1203.
7. Hall AK, Mills SL, Lund PK. Clinician–investigator training and the need to pilot new approaches to recruiting and retaining this workforce. *Academic Medicine*. 2017;92(10):1382.
8. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
9. NIH. Physician-scientist Workforce (PSW). Working Group Report. NIH Web site. http://acd.od.nih.gov/reports/PSW_Report ACD_06042014.pdf. Updated June 1, 2014. Accessed February 3, 2020. 2. NIH. Biomedical Research Workforce. 2014.
10. Ommering BWC, van Blankenstein FM, Wijnen-Meijer M, van Diepen M, Dekker FW. Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. *BMJ open*. 2019;9(7):e028034.
11. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one*. 2015;10(6):e0127470.
12. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching*. Dordrecht: Springer Science + Business Media; 2014.
13. Bierer SB, Chen HC. How to Measure Success: The Impact of Scholarly Concentrations on Students-A Literature Review. *Academic Medicine*. 2010;85(3):438-452.
14. Radville L, Aldous A, Arnold J, Hall AK. Outcomes from an elective medical student Research Scholarly Concentration programme. *Journal of investigative medicine*. 2019;67(6):1018-1023.
15. DiBiase RM, Beach MC, Carrese JA, et al. A medical student scholarly concentrations programme: scholarly self-efficacy and impact on future research activities. *Medical Education Online*. 2020;25(1):1786210.
16. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programmes and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
17. Kool A, Mainhard T, Jaarsma D, van Beukelen P, Brekelmans M. Effects of honours programmeme participation in higher education: a propensity score matching approach. *Higher Education Research & Development*. 2017;36(6):1222-1236.

18. Ommering BWC, Wijnen-Meijer M, Dolmans DHJM, Dekker FW, van Blankenstein FM. Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. *BMC Medical Education*. 2020;20(1):204.
19. Ajzen I. The theory of planned behavior. *Organizational behavior and human decision processes*. 1991;50(2):179-211.
20. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
21. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017;65(5):942-948.
22. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009*. Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
23. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
24. Ommering BWC, van den Elsen PJ, van der Zee J, Jost CR, Dekker FW. Using an Extracurricular Honours Programme to Engage Future Physicians Into Scientific Research in Early Stages of Medical Training. *Medical Science Educator*. 2018;28(2):451-455.
25. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications; 2017.
26. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, eds. *Measures in health psychology: A user's portfolio. Causal and control beliefs*. Windsor, UK: NFER-NELSON; 1995:35-37.
27. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L, Freeman KE. *Manual for the Patterns of Adaptive Learning Scales (PALS)*. Ann Arbor: University of Michigan2000.
28. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International*. 2016:1-8.
29. Litman JA. Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences*. 2008;44(7):1585-1595.
30. Netten AP, Dekker FW, Rieffe C, Soede W, Briaire JJ, Frijns JH. Missing Data in the Field of Otorhinolaryngology and Head & Neck Surgery: Need for Improvement. *Ear and Hearing*. 2017;38(1):1-6.
31. Waaijer CJF, Ommering BWC, van der Wurff LJ, van Leeuwen TN, Dekker FW, Education NSIGoS. Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. *Perspectives on Medical Education*. 2019;8(4):223-229.
32. Ranieri V, Barratt H, Fulop N, Rees G. Factors that influence career progression among postdoctoral clinical academics: a scoping review of the literature. *BMJ open*. 2016;6(10):e013523.

11

How does engaging in authentic research at undergraduate level contribute to student wellbeing?

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Submitted

Abstract

In the context of rapidly growing numbers of university students reporting that they have experienced mental health problems, this paper argues that doing research as an undergraduate can contribute to student wellbeing. We propose authenticity as a conceptual lens against which to situate student capabilities for wellbeing. The paper explores the way in which research-based learning accesses intrinsic motivation, then looks at a means of fostering authenticity through a framework of competence, autonomy, and relatedness. We argue that a sense of belonging and perceived personal competence are among the many beneficial outcomes of an authentic undergraduate research experience. A research-based learning experience provides opportunities to develop close working relationships with faculty members, and to identify as a researcher, as well as access to inclusive and productive learning spaces. Specific curriculum design approaches and faculty practices to avoid student isolation, overwhelming autonomy or conversely excessive faculty control and sub-optimal levels of challenge are outlined. With case studies drawn from Medicine and Geography, we demonstrate how authentic research-based learning can form an entitlement for all students in an embedded curriculum-based approach. The exemplars are used to tease out broader curriculum design principles and effective pedagogic practice. The paper advocates for research-based learning to begin early in the undergraduate curriculum, in order to establish a sense of belonging for students and healthy learner-centred pedagogy. We conclude that developing nurturing and inclusive learning spaces and the cultivation of high-quality relationships between staff and students are often unrecognised aspects of student wellbeing.

Introduction

Student wellbeing - a growing concern

Mental health issues affect a large proportion of the general population over the course of their life. The 'Health Survey for England 2014' showed 26% of all adults reported having ever been diagnosed with at least one mental illness and a further 18% reported having experienced a mental illness without a formal diagnosis.[1] Higher Education has seen rapidly growing numbers of university students reporting that they have experienced mental health problems in what has been described as a 'campus mental health crisis'.[1,2] In 2015 and 2016, over 15,000 first-year students in UK universities reported that they had a mental health problem, compared to approximately 3,000 in 2006.[3] Lipson et al. (2016) revealed significant disciplinary differences in wellbeing statistics across 48,667 university and college undergraduates in the USA.[4] Undergraduate prevalence rates (at least one mental health problem) ranged from 28% in Public Health rising to 45% in Art and Design. Treatment rates also varied widely from the lowest at 25% in Engineering to the highest rate of 50% in Social Work. Furthermore, a systematic review and meta-analysis of 183 studies in over 40 countries, specifically amongst medical students, showed a prevalence of depressive symptoms of 27.2%.[5] Regardless of discipline, marginalised students are at greatest risk of low levels of wellbeing, with disabled students more than any other group being at highest risk.[6] Feelings of belonging and self-efficacy are essential for wellbeing, therefore relative student attainment can also translate into feelings of belonging or conversely, marginalisation. Persistent attainment gaps across higher education highlight underserved populations, and challenge educational providers to offer inclusive spaces for learning and inclusive pedagogy.[7]

When students were asked to explore wellbeing solutions in focus groups, these included opportunities for: mentoring and networking; finding social spaces; and developing nurturing social environments, and significantly students wanted to have a voice in developing these opportunities.[6] We therefore argue that *learning spaces* as well as the *nature of staff-student and student-student relationships*, are important in creating a healthy learning environment for all. This paper argues that a sense of belonging and perceived personal competence are among the many beneficial outcomes of an authentic undergraduate research experience (particularly a mentored one). A research-based learning experience provides opportunities to develop close working relationships with faculty members, and to identify as a researcher, as well as access to inclusive and productive learning spaces. Hence, an undergraduate research experience can comply with the need to create learning spaces and support staff-student and student-student relationships in such a way that a healthy learning environment is created and, as a result, wellbeing is enhanced.

Learning spaces

Self-authorship is the ability to know oneself, to know what one knows, to reflect upon it and to base judgements on it.[8] This includes an individual's sense of who they are, what they believe, and their construction of relationships. It is highly applicable to research-based learning where the nature of knowledge is questioned critically through engagement in doing research and communicating research findings. Self-authorship has been linked to borderland learning spaces, those places where learners can develop mature working relationships, embrace and value diversity, and give consideration to multiple perspectives.[9] These spaces are conceived of as unfamiliar physical or metaphorical territories whose novelty and ambiguity offer a challenge, which can seem daunting to students and faculty.[9] For undergraduate researchers this novelty may include the field of data collection, data analysis (e.g. statistics), academic conferences, online journals, or even just doing research or being mentored, where these are unfamiliar pedagogic approaches (albeit sometimes delivered in familiar spaces). According to Bandura's Social Cognitive Theory, these daunting and ambiguous activities pre-eminently accommodate opportunities to increase self-efficacy beliefs through fostering success experiences, in turn contributing to feelings of wellbeing.[10]

Learning spaces dedicated to discuss research with others (faculty and other student researchers), include undergraduate research conferences,[9,11-13] as well as spaces for virtual dialogue, e.g. online journals.[14-16] Engaging in dialogue with other student researchers can lead to a reciprocal and elucidatory student-led pedagogy.[13] Pavlakou and Walkington (2018) elicited surprising responses from students in relation to their experience of a multidisciplinary institutional undergraduate research conference.[17] Students reported that they felt a sense of isolation within their discipline, but during the institution-wide conference were able to break away from the 'bubble' of their discipline and feel part of the wider academic community. A sense of belonging to the institution was also created due to the multidisciplinary nature of the event. Interestingly in terms of space, it was a 'pop up' event in a familiar social space in the centre of the campus, and fully open to the public. Such borderland learning spaces can be transformatory, with students experiencing a liminal state which can result in an identity change from student to researcher. Barr (2017), writing about a student-run Games Studies journal, noted that the journal's Facebook group has nearly 400 members and beyond developing 'video game scholarship' (including academics citing student research), provides a sense of community, with the most valued aspect of the journal being students learning from peer feedback.[16]

Nature of staff-student and student-student relationships

An undergraduate research experience specifically offers possibilities to develop and support close working relationships with both faculty members as well as peer-researchers. These close working relationships contribute to feelings of being part of a community. According to Chang and Ramnanan (2015) undergraduate research experiences not only benefit research specific skills, but interpersonal skills as well.[18] Their systematic review revealed that interaction with faculty is an important motivating factor and a paucity of mentors or faculty guidance was labelled as demotivating. In line with this, Möller et al. (2015) identified 'independence and collaboration' as one category of salient learning outcomes related to personal development.[19] Furthermore, undergraduate research has been shown to offer particular gains for students from underserved populations,[20,21] with mentoring accounting for the leveraging effect of research as a transformatory experience for students. Therefore, understanding what makes for effective mentoring has become a focus of recent research.[22-24] In short, effectively mentored research experiences can benefit student wellbeing through motivating students and supporting transformatory experiences (e.g. developing a researcher identity and evolving into a research producer instead of consumer). Associated with this, the mentoring of undergraduate researchers can also benefit staff in terms of academic identity and career development.[25]

An undergraduate research experience has multiple beneficial outcomes for a diversity of students,[26-28] underlining the need for experiences to be embedded in the curriculum to reach all students. Yet students most often experience research late in their undergraduate education, for instance first starting by learning about research (the 'research informed' teaching of Healey and Jenkins),[29] and only engage in 'research-based' learning in later years as part of a final year or capstone project. Walkington et al. (2011) and Ommering et al. (2020) called for research-based experiences to be embedded much earlier in undergraduate curricula, while acknowledging that framing inquiry, the first step in the research process, is one of the most challenging to teach.[30,31] In first year courses, Levy and Petrulis (2012) noted that when students were offered opportunities to frame lines of inquiry and build knowledge themselves, they found this empowering for their intellectual and personal development, but faculty support was necessary.[32] According to Thiry and Laursen (2011) undergraduate research mentors offer three forms of support to students: support for intellectual development, for personal and emotional development, and for professional socialisation.[33]

This paper now explores the way in which student capabilities for wellbeing can be enhanced through engaging in research, using authenticity as a conceptual lens. It begins with the way in which research-based learning accesses intrinsic motivation, then looks at a means of fostering authenticity through a framework of competence, autonomy, and relatedness. Exemplars from medical and geographical education are offered to tease out broader curriculum design principles and effective pedagogic practice to maximise opportunities for student wellbeing through research-based learning.

Theoretical framework

Self-Determination Theory (SDT), developed by Ryan and Deci, is an empirically based theory of human behaviour and personality development. SDT addresses social conditions that aid or obstruct human flourishing, examining how inherent human capabilities for engagement and wellbeing can either be enhanced or undermined. Contrary to other motivational theories, SDT states that the presence of motivation (i.e. quantity of motivation) is not sufficient in order to support human flourishing and feelings of wellbeing. Rather, SDT focuses on the *quality* of motivation, suggesting that some forms of motivation are completely volitional, while other forms are entirely external. A central distinction in SDT is intrinsic versus extrinsic motivation. Intrinsic motivation can be defined as pursuing an activity out of pure interest, benefiting personal feelings of enjoyment. Extrinsic motivation entails pursuing an activity for externally located consequences, like an external reward or social approval. According to SDT, intrinsic motivation can foster academic performance, deep learning, and wellbeing.[34]

SDT suggests that satisfaction of three basic psychological needs is imperative in order to elicit and sustain intrinsic motivation, which in turn leads to feelings of wellbeing. First is the need for autonomy, defined as the need to self-regulate experiences and actions. Autonomy relates to feeling volitional and self-endorsed, compatible with one's own authentic interests and values. Second is the need for competence, or the need for feelings of mastery and efficacy in navigating within relevant contexts. Third is the need for relatedness, concerning the need to feel socially connected with and cared for by others. However, equally important is to feel significant among and contribute to other people. Beyond the individual, relatedness pertains to being part of social organizations, resulting in feelings of belonging.[34,35] This aligns with much SDT driven research which has shown that educational contexts in which autonomy is supported, structure is provided to aid competence, and relatedness is pursued, foster personal wellbeing.[34,36]

From an SDT perspective, intrinsic motivation to learn can evolve from autonomy, competence, and relatedness, as experienced through engaging in research. Consequently, a valuable avenue for enhancing student wellbeing emerges where this can be embedded in the curriculum for every student. However, in order to flourish, all three psychological needs must be satisfied.[34,35] Feelings of autonomy can be promoted by giving students the freedom to make significant choices within their research project, offering chances to self-regulate the research experience, enhancing compatibility with authentic interests and values. Furthermore, students can be stimulated to take a leading role in carrying out research, adding to feelings of volition and self-endorsement.[31] However, within undergraduate education, most students are encountering research experiences for the first time. This implies that, complementary to autonomy support, competence support should be pursued as well. Specifically, mentoring is of great value for stimulating students to feel effective in navigating the difficult research landscape. While cooperating with students, mentors could create the right environment by setting achievable targets and formulating clear research goals.[24] Furthermore, while the student conducts research autonomously, a mentor can closely monitor progress and offer support when needed.[31] Hereby, the mentor provides social guidance as well, contributing to students' feelings of being cared for by others, one part of the need for relatedness. In order to fully establish relatedness, students need to feel that they are significant members of the research endeavour, so a sense of community can be established in which the students are involved.[22,24] In sum, students' wellbeing can be enhanced through their intrinsic motivation to learn by shaping undergraduate research experiences in such ways that students are given the opportunity to self-regulate their research experience, while being supported and socially guided by a mentor and within a research community.

In their perspective on authenticity within undergraduate research experiences, Wald and Harland (2017, 758) state that "the authentic model of teaching through research should promote students' *sense of ownership over the research, which is achieved by entrusting them with the responsibility for the work and care for their peers*, *while teachers provide expert support*".[37] Here, the sense of ownership over the research and responsibility for the work is an illustration of what distinguishes a research-based learning curriculum from a research-informed curriculum. That is, in order to support an identity shift from research consumer to research producer, students need to own and care about their research. Furthermore, when looking at this statement through the lens of SDT, similarities can be identified with the three psychological needs. Promoting students' sense of ownership and entrusting them with responsibilities is in accordance with the need for autonomy, while the responsibility to care for peers strengthens feelings of social connectedness and of being significant contributors within the research community, which is similar to the need for relatedness. Lastly, teachers providing expert support is in line with the need for competence. For instance by setting appropriate performance expectations, offering students constructive feedback and working towards a public demonstration of competence - all of which were identified by Kuh and O'Donnell (2013) as elements of high impact practices to achieve successful outcomes for undergraduate students - teachers, or mentors, can promote feelings of mastery and efficacy among students.[38] Hence, the psychological needs could be viewed as conditions that foster authenticity as well.

Authenticity in research-based learning – a framework

Wald and Harland (2017) proposed a theoretically-informed and practice-oriented framework for authenticity in the context of research-based learning.[37] Three ways to understand authenticity were identified: 1) authenticity as relating to the real world, 2) the existential authentic self, and 3) a degree of meaning.

The most popular and commonly used perspective connecting authenticity with research-based learning is *authenticity as relating to the real world*, referring to learning that mirrors the real world. It differs from traditional courses as it aligns with how actual scientists do their work and proposes that students should experience how knowledge is produced and utilised in real life, preparing them for future professional practice. Hence, it relates to John Dewey's vision of learning-by-doing.[39]

The second way to understand authenticity in undergraduate research experiences, is that of *the existential authentic self*. It relates to developing a sense of self and self-identity, where the idea of 'ownership' is crucial to becoming an independent learner. Furthermore, it encompasses being true to one's self, both ideas encapsulated in the 'self-authorship' concept.[8] A pivotal point herein with regard to the teacher-student relationship is that teachers and students learn in dialogue and share responsibilities for mutual growth.

The third explanation of authenticity relates to *a degree of meaning*, which is a requirement for perceiving something as authentic. It relates to fostering personal meaning within the learning experience, which is best accomplished by engaging students in their own quest for knowledge. What is regarded as being meaningful depends on what students, personally, deem important or valuable. This sense of personal meaning is, however, created between and shared with others, as students are part of a wider community.

Case studies

The two vignettes below offer insights into how real-world, authentic self, and degree of meaning contribute to authenticity in research experiences, one is within medical education, the other in geography. Both vignettes provide accounts of curriculum embedded experiences early in the undergraduate curriculum and demonstrate the importance of ownership by the student and their own sense of responsibility for both the research and its dissemination, thus completing the research cycle.

Vignette 1: Leiden University Medical Center – Individual clinical research arising from patient bedside experiences

Connecting research with clinical practice is pivotal to involve scientific knowledge in clinical decision making and make advancements within medicine.[40] Subsequently, 'scholar' is one of the roles a medical graduate should master.[41] Leiden University Medical Center implemented a mandatory research course for all first-year medical students to conduct clinical research. Every student individually conducts a small research project, being involved in gathering and processing patient data (i.e. each student collects detailed data from three patients, combining their data into a large shared dataset), formulating an individual research question, analysing data, writing a research report, and presenting their research to a critical audience in a simulated conference setting. As students are engaged in every step of the research process and gather data from real patients, it mirrors how clinician-scientists perform research in professional practice. Students are mentored by a researcher (e.g. clinician, academic, PhD candidate), but are free to formulate their own research question and have a leading role in the implementation of their research. Hence, the experience aligns with authentic interests, and feelings of responsibility and ownership are supported. Furthermore, by offering students the possibility to formulate their research question 'at the bedside of the patient' (i.e. based on personal experiences within an internship in a nursing home), the research project is deemed personally meaningful.

Vignette 2: Oxford Brookes University Geography – Peer-mentored international research-based learning in the field
Fieldwork is a signature pedagogy for the discipline of geography and field-based research forms an important element of a geography degree.[42] In the three-year undergraduate honours degree in Geography at Oxford Brookes University (UK) students undertake a group research investigation which runs throughout the second year. Students work as a small team to design their research in semester 1, collect primary data on international residential fieldwork in the inter-semester break, then return in semester 2 to analyse data and complete individual written reports. Students are supported through all phases of the research cycle[14,43] by a year 3 student peer-mentor and a faculty mentor.[44] The investigation not only takes place in the real-world but also mirrors being an academic or professional geographer, including the option to publish the results in a journal article for a public audience. The students take part in 'self-authoring,' understanding their own opinions and values as well as eliciting research findings as part of engaging in the research. This combines personally meaningful learning with a strong degree of autonomy.

These vignettes highlight how two disciplines have embedded research opportunities for every student on a programme. However, simply instructing students to go and do real–world research is insufficient to ensure successful outcomes. Students could easily feel overwhelmed or isolated if the curriculum architecture and faculty support are not in place to ensure positive learning experiences for everyone. The examples showed how there was the potential for student research to 'make a difference' in multiple authentic ways: for instance to wider society, or within the scientific project, both of which can promote feelings of care among students, as well as benefiting personal intellectual growth. Next, we outline curriculum design features and salient practices for inclusive and high quality mentored undergraduate research experiences using Wald and Harland's framework for authenticity.

The design and practice of research-based learning for authenticity

Through extensive empirical study, Kuh and O'Donnell (2013) have distilled the common features or 'elements' of high impact practices from Higher Education settings which translate into successful outcomes for students at undergraduate level.[38] Providing all students with opportunities to access these elements may be challenging and costly, yet they also have the potential to enhance wellbeing through increasing motivation and attainment. Research-based learning, particularly an early experience of research, is eminently placed to foster many of these elements where curriculum design and mentoring are mutually supportive. Ommering et al. (2020) proposed twelve tips to design a research course embedded within large scale education, while still allowing every student to conduct research individually.[31] In order to ensure successful outcomes, effective mentoring is needed and Shanahan et al. (2015) identified ten salient practices (SP) for effective research mentoring.[22] This section explores the way in which curriculum design and mentoring practices can enhance authenticity, and therefore wellbeing, in research–based learning.

Real-world research

Learning-by-doing, which is seen as an effective way to enhance skills and capabilities among students,[45] is a key objective when offering an experiential opportunity within the core curriculum. Passive learning approaches are believed to diminish curiosity,[30,46] corroborating the need for active learning approaches, as curiosity is identified as a prerequisite for motivation.[47,48] Curiosity is especially provoked within the context of real-world problems, elucidating emotion. Thus, in order to trigger curiosity, truly raise motivation, and ultimately promote student wellbeing, learning should mirror the real world.[49] A successful research-based learning approach within the curriculum should use relevant real-world examples to stimulate curiosity (tip 4) and engage students in every stage of the scientific research process (tip 1). In this way, students become acquainted with how actual scientists do their work and a shift from research consumer to research producer can be established. Here, the mentor plays an important role. Teaching the technical skills, methods, and techniques of conducting research in the discipline (SP3), is often seen as the primary responsibility

11

of a research mentor, particularly relating to ethical and professional practice, but it also affords an opportunity to ensure that research skills match students' aspirations and are personalised as far as possible. This enables students to feel a connection to their discipline (relatedness) through research that interests them and is of wider relevance as a means to contribute to their wellbeing. Creating opportunities for peers and near-peers to mentor each other (SP9) can broaden scholarly opportunities so that students not only see the relevance of their own real-world research but also learn how their discipline is created through the research endeavours of others, and they can contribute in mutually supportive ways. As dissemination of scientific work is the last step within the research process, students should be encouraged and supported to share findings (SP10) by writing a professional academic piece (tip 10), presenting orally (tip 11), and receiving feedback (tip 12) from their mentor. This practice, also reflected in Kuh and O'Donnell's (2013) 'Public demonstration of Competence' element,[38] offers students opportunities to publicly demonstrate new knowledge and skills, which fosters wellbeing through need-satisfaction and motivation.

Existential authenticity through research

For research-based learning to be authentic, students need to *become* researchers.[50] Emerging researcher-identities should be fostered and need to align with a student's own values. This relates to the definition of authenticity by Ryan and Deci (2017), who emphasized that one's behaviour needs to be endorsed by the self.[34] An embedded research course should therefore foster the existential authentic self, especially if the aim is to enhance motivation and subsequently wellbeing. By providing research experiences in large group sessions (tip 6), possibilities are created to reach all groups of students, offering them a solid research-related foundation. Subsequently, smaller group sessions can be used to help students develop more in-depth research knowledge and immerse themselves in research, which contributes to developing a researcher-identity and feelings of becoming a researcher. Furthermore, smaller group sessions allow for hands-on one-to-one mentoring (SP6). Often, mentors are researchers themselves, who can become inspiring role models for students. Using inspiring researchers as teachers of small group sessions (tip 8) enhances positive perceptions of, and motivation for, research among students. It also provides students with a real-world image of a researcher to serve as an example. Becoming a researcher can be an uncomfortable existential leap from being 'just a student',[11] and is strongly associated with identity development and therefore wellbeing status. Students who identify as researchers and even 'mini professionals' as a result of engaging in research, have been through a challenging process, yet have proven their resilience and this has contributed to a sense of self-efficacy. One of the most fundamental roles of an academic research mentor, therefore, is balancing high expectations and an appropriate sense of challenge with a safety net of support in line with students' need for competence and relatedness.[24] As Ryan and Deci stated (2017, 11) competence "wanes in contexts in which challenges are too difficult, negative feedback is pervasive, or feelings of mastery and effectiveness are diminished or undermined by interpersonal factors such as person-focused criticism and social comparisons".[34] Achieving the balance between giving students freedom and taking too much control of the research is something that takes time to develop and involves good knowledge of, and interest in, individual undergraduates (SP4) who are novice researchers. While it is important to stretch students by providing a sense of challenge,[24] it is also important to provide a scaffolded support structure (tip 7) so that students can build their confidence against an authentic sense of potential for failure in their research project. Academic mentors therefore need to respond to students' varying needs and abilities (SP1) throughout the research process as these may differ between individuals and throughout the research process. Setting clear expectations (SP2) is important, and ensuring that these are progressively raised is something that can only come with hands-on mentoring (SP6). According to Wald and Harland's framework, a pivotal perspective regarding the existential authentic self is that mentors and students learn in dialogue, sharing responsibilities for mutual growth.[37] Existential authenticity in research can therefore be supported through professional socialisation support, personal and emotional support, and intellectual support.[33] This can also contribute to faculty identity development and the wellbeing associated with developing effective mentoring practice.[25]

Personal meaning

In order to perceive an activity as authentic, it needs to have personal meaning or relevance. A requirement to promote deep learning is that students should experience relevance within a real-world environment.[49] Stimulating students to collect real-world data to answer relevant research questions (tip 2) explicitly connects research to practice, which is related to increased feelings of meaning and motivation. Furthermore, students should be given autonomy in conducting their own research project (tip 5). This could be established by granting students responsibilities regarding the implementation of the research project, mentoring students so they can take progressively greater ownership as the project proceeds (SP7). In this way, students are leading their own quest for knowledge, which plays a significant role in perceiving an activity as meaningful and developing a researcher-identity. The professionalisation of this identity can be enhanced through networking with others e.g. other faculty members, or faculty beyond the university. Mentoring students in the ways they act in professional spaces can be a means of introducing them further to the norms of their discipline (SP8). Moreover, personal meaning is also created between, and shared with others, reflecting the importance of feelings of belongingness and feeling part of a community (i.e. students' need for relatedness). Distributing data collection across all students (tip 3) therefore not only helps to make an embedded research course feasible, but also contributes to feelings of social interdependence among students.[51] A sense of ownership also sustains student engagement with their studies, discipline, and even institution. Students who have presented their disciplinary research in multidisciplinary fora have reported a sense of wellbeing from connecting to those beyond their discipline akin to 'removing blinkers'.[13] This sense of being part of a community that can contribute to knowledge creation is a powerful means to create wellbeing as it relates to connectedness, altruism, a healthy work ethic, and clear sense of purpose. In disciplines where research is team based, as is often the case early in degree programmes, building a sense of community among the research team (SP5) is highly effective, although perhaps one of the most difficult practices to enact in some disciplines, hence the need to create fora for sharing, such a conferences and dedicated student journals. Socially connecting students could be strengthened by implementing peer discussion within the research course (tip 9). Moreover, by giving students possibilities to guide each other and stimulate peer discussion, deep learning is enhanced.[22] In this way, a platform is created in which students help each other, which stimulates the need for relatedness. Lastly, by seeing a peer or near-peer succeed in the same complex task, students' self-efficacy beliefs will be enhanced as well, which is related to higher levels of motivation and wellbeing.[10] Taken together, these strategies help to foster authenticity by increasing the degree of meaning, while also stimulating feelings of relatedness to contribute to students' feelings of wellbeing.

Discussion

This paper has demonstrated how authenticity within research-based learning can be embedded in the curriculum and made available to all students. Active engagement in research can move students away from adopting a research 'consumer' identity, with higher student-as-consumer orientation at undergraduate level being associated with lower academic performance.[52] Instead a student-as-producer identity, where social learning takes place, can be transformatory,[53] giving students agency and voice. Together the students experience research as it is undertaken by professionals in their discipline, combining a curriculum requirement with an authentic question and output. Both vignettes offered a complete research cycle within a module, ending in authentic research dissemination and outlined authentic research-based learning early in the undergraduate experience. The spaces created for this sharing of research are dialogic, allowing for refinement and reworking in dialogue with academics, peers or near-peers (e.g. postgraduates). The settings are deliberately high stakes and professional, where students can begin to experience an evolving researcher identity and sense of achievement. The research environment is fully collaborative, every individual's data matters to the wider project, and this is important in ensuring inclusivity and avoiding the sense of isolation that individual study could create. The paper has shown how good curriculum design is essential[31] but, in addition, effective mentoring practices[22,24] ensure that all students can achieve positive experiences of the curriculum in a personalised support structure which safeguards wellbeing as students engage with research.

Striving towards a student transition from research consumer to research producer not only makes an undergraduate research experience authentic, it also contributes to need-satisfaction and ultimately wellbeing. That is, within learning spaces that support beneficial staff-student and student-student relationships, wellbeing can be supported through enhancing feelings of autonomy, competence, and relatedness among students. These psychological needs provide the conditions to foster authenticity, but also strengthen inclusive and nurturing environments in higher education in which students can develop their sense of personal fulfilment. Feelings of belonging and self-efficacy can be developed and reinforced in spaces which are continually enriched through authentic participation.

In adopting an authenticity framework this paper has argued for a research-based learning experience for all students in an environment supported by experts to develop ownership, responsibility, and care for peers which contributes to student wellbeing. An important distinction exists between students carrying out research in a group or social setting and the ingredients needed for authentic co-production.

In the latter case, learning by doing research is coupled with reciprocal learning through dialogue with other researchers (peer researchers, near-peer researchers or in research mentoring relationships). In this way, Habermas' 'ideal speech act',[54] where the power differential of teacher and learner is replaced with communication as co-producers, links to the importance of students learning together and from each other in supportive and inclusive learning spaces. The learning spaces, whether real, virtual or imagined are also important from a wellbeing perspective, as they can help to avoid learner isolation, give room to open up dialogue and provide opportunities for students to be truly active in research, guided by curiosity, connecting to others around them and thereby to developing their skills in lifelong learning. This research suggests that in addition to the existing framework for authenticity, further attention should be paid to the quality of learning spaces (novelty, professionalism, inclusivity) and the practice based elements for effective relationships between learners and teachers such as mentoring to ensure the wellbeing of all involved.

References

1. Guthrie S, Lichten CA, van Belle J, Ball S, Knack A, Hofman J. *Understanding mental health in the research environment: A Rapid Evidence Assessment.* Santa Monica, CA: RAND Corporation; 2017.
2. Schwartz V, Kay J. The crisis in college and university mental health. *Psychiatric Times*. 2009;26(10):32.
3. Research IfPP. Not by degrees: improving student mental health in the UK's universities. 2017; Available at https://www.ippr.org/research/publications/not-by-degrees Accessed 12/05, 2020.
4. Lipson SK, Zhou SS, Wagner B, Beck K, Eisenberg D. Major Differences: Variations in Undergraduate and Graduate Student Mental Health and Treatment Utilization Across Academic Disciplines. *Journal of College Student Psychotherapy*. 2016;30(1):23-41.
5. Rotenstein LS, Ramos MA, Torre M, et al. Prevalence of Depression, Depressive Symptoms, and Suicidal Ideation Among Medical Students A Systematic Review and Meta-Analysis. *Jama*. 2016;316(21):2214-2236.
6. Oman S. Student Experience Survey 2017: investigating well-being at university. 2017. Accessed 23 April 2020.
7. Tatlow P. Participation of BME students in UK Higher Education. In: Alexander C, Arday J, eds. *Aiming Higher: Race, Inequality and Diversity in the Academy*. London: Runnymede; 2015.
8. Baxter Magolda MB. Self-authorship as the common goal of 21 st century education. In: Baxter Magolda MB, King PM, eds. *Learning partnerships: Theory and models of practice to educate for self-authorship* Sterling, VA Stylus; 2004:1-35.
9. Hill J, Walkington H, Kneale PE. Borderland spaces for undergraduate teaching and learning in higher education. In: Bilham T, Hamshire C, Hartog M, Doolan M, eds. *Reframing Space for Learning: Empowering Innovation in University Teaching and Learning.* London: UCL IOE Press 2019.
10. Bandura A. *Self-Efficacy. The Exercise of Control.* New York: Freeman; 1997.
11. Hill J, Walkington H. Developing graduate attributes through participation in undergraduate research conferences. *Journal of Geography in Higher Education*. 2016;40(2):222-237.
12. Kneale P, Edwards-Jones A, Walkington H, Hill J. Evaluating undergraduate research conferences as vehicles for novice researcher development. *International Journal for Researcher Development*. 2016;7(2):159-177.
13. Walkington H, Hill J, Kneale PE. Reciprocal elucidation: a student-led pedagogy in multidisciplinary undergraduate research conferences. *Higher Education Research & Development*. 2017;36(2):416-429.
14. Walkington H. Geoverse: piloting a National e-journal of undergraduate research in Geography. *Planet*. 2008;20(1):41-46.
15. Walkington H. Developing Dialogic Learning Space: The Case of Online Undergraduate Research Journals. *Journal of Geography in Higher Education*. 2012;36(4):547-562.
16. Barr M. Press Start: the value of an online student-led, peer-reviewed game studies journal. *Research in Learning Technology*. 2017;25.
17. Pavlakou M, Walkington H. Multidisciplinary undergraduate conferences – A new pedagogy for student learning? 2018. Accessed 06/05/2020.
18. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
19. Moller R, Shoshan M, Heikkila K. What is the reward? Medical students' learning and personal development during a research project course. *Medical Education Online*. 2015;20.

20. Brownell JE, Swaner LE. *Five high-impact practices: Research on learning outcomes, completion, and quality*. Washington DC: Association of American Colleges and Universities 2010.
21. Finley A, McNair T. *Assessing Underserved Students' Engagement in High-Impact Practices*. Washington DC: Association of American Colleges and Universities 2013.
22. Shanahan JO, Ackley-Holbrook E, Hall E, Stewart K, Walkington H. Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature. *Mentor Tutor*. 2015;23(5):359-376.
23. Vandermaas-Peeler M, Miller PC, Moore JL. *Excellence in mentoring undergraduate research*. Washington DC: Council on Undergraduate Research; 2018.
24. Walkington H, Stewart KA, Hall EE, Ackley E, Shanahan JO. Salient practices of award-winning undergraduate research mentors - balancing freedom and control to achieve excellence. *Studies in Higher Education*. 2019.
25. Hall EE, Walkington H, Shanahan JO, Ackley E, Stewart KA. Mentor perspectives on the place of undergraduate research mentoring in academic identity and career development: an analysis of award winning mentors. *International Journal for Academic Development*. 2018;23(1):15-27.
26. Boyd MK, Wesemann JL. *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*. Washington DC: Council on Undergraduate Research; 2009.
27. Jones MT, Barlow AEL, Villarejo M. Importance of Undergraduate Research for Minority Persistence and Achievement in Biology. *Journal of Higher Education*. 2010;81(1):82-115.
28. Kendricks KD, Nedunuri KV, Arment AR. Minority student perceptions of the impact of mentoring to enhance academic performance in STEM disciplines. *Journal of STEM Education: Innovations & Research*. 2013;14:38.
29. Healey M, Jenkins A. *Developing undergraduate research and inquiry*. York: Higher Education Academy; 2009.
30. Walkington H, Griffin AL, Keys-Mathews L, et al. Embedding Research-Based Learning Early in the Undergraduate Geography Curriculum. *Journal of Geography in Higher Education*. 2011;35(3):315-330.
31. Ommering BWC, van Diepen M, van Blankenstein FM, de Jong PGM, Dekker FW. Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students. *Medical Teacher*. 2020;42(10):1128-1133.
32. Levy P, Petrulis R. How do first-year university students experience inquiry and research, and what are the implications for the practice of inquiry-based learning? *Studies in Higher Education*. 2012;37(1):85-101.
33. Thiry H, Laursen SL. The Role of Student-Advisor Interactions in Apprenticing Undergraduate Researchers into a Scientific Community of Practice. *Journal of Science Education and Technology*. 2011;20(6):771-784.
34. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications; 2017.
35. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
36. Reeve J, Ryan RM, Deci EL, Jang H. Understanding and promoting autonomous self-regulation: A self-determination theory perspective. In: Schunk D, Zimmerman B, eds. *Motivation and self-regulated learning: Theory, research, and application*. Mahwah, NJ: Erlbaum; 2007:223-244.
37. Wald N, Harland T. A framework for authenticity in designing a research-based curriculum. *Teaching in Higher Education*. 2017;22(7):751-765.

38. Kuh GD, O'Donnell K. *Ensuring Quality & Taking High-impact Practices to Scale.* Washington D.C.: AAC&U, Association of American Colleges and Universities; 2013.
39. Dewey J. *Democracy and education.* Mineola, NY: Dover Publications, Inc. ; 2004.
40. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator.* 2011;21:258-260.
41. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report.* Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
42. Shulman LS. Pedagogies of uncertainty. *Liberal Education.* 2005;91(2):18-25.
43. Spronken-Smith RA, Brodeur JJ, Kajaks T, et al. Completing the research cycle: A framework for promoting dissemination of undergraduate research and inquiry. *Teaching & Learning Inquiry.* 2013;1(2):105-118.
44. Satow C, Medby I, Walkington H, et al. Enhancing wellbeing through collaborative development of a digital, geographical research techniques guide. RGS Annual International conference; 2019; London.
45. Chickering AW, Gamson ZF. Seven principles for good practice in undergraduate education. *AAHE bulletin.* 1987;3:7.
46. Scheyvens R, Griffin AL, Jocoy CL, Liu Y, Bradford M. Experimenting with active learning in geography: Dispelling the myths that perpetuate resistance. *Journal of Geography in Higher Education.* 2008;32(1):51-69.
47. Willison J, O'Regan K. Commonly known, commonly not known, totally unknown: a framework for students becoming researchers. *Higher Education Research & Development.* 2007;26(4):393-409.
48. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one.* 2015;10(6):e0127470.
49. Merrill MD. First principles of instruction. *Educational Technology Research and Development.* 2002;50(3):43-59.
50. Thiry H, Laursen SL, Hunter AB. What Experiences Help Students Become Scientists? A Comparative Study of Research and Other Sources of Personal and Professional Gains for STEM Undergraduates. *Journal of Higher Education.* 2011;82(4):357-+.
51. Johnson DW. Social interdependence: Interrelationships among theory, research, and practice. *American Psychologist.* 2003;58(11):934-945.
52. Bunce L, Baird A, Jones SE. The student-as-consumer approach in higher education and its effects on academic performance. *Studies in Higher Education.* 2017;42(11):1958-1978.
53. Neary M. Student as producer: a pedagogy for the avant-garde? *Learning Exchange.* 2010;1(1).
54. Boud D, Cohen R, Sampson J. Introduction: Making the move to peer learning. In: Boud D, Cohen R, Sampson J, eds. *Peer Learning in Higher Education: Learning From & With Each Other.* London: Kogan Page; 2002.

12

Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students

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Abstract

Engaging students in research during medical school could contribute to creating an academic attitude among students, which underlies practicing evidence-based medicine in future professional practice. However, attempts to involve undergraduate students in research during medical training remain inadequate. Most medical schools educate large numbers of students at the same time, especially in early phases of medical training. Large scale education on the one hand and individually providing students with authentic research experiences on the other hand is considered not that easy to achieve. Drawing on our own experiences, existing literature, and theories we propose twelve tips to design and implement a course in which authentic individual research experiences can be provided to a large group of undergraduate students.

Introduction

In professional practice, all physicians should be able to use research. *Using research* entails that physicians are aware of the newest developments within healthcare, are able to critically appraise scientific literature, and to involve scientific knowledge in clinical decision making.[1,2] Thereby, physicians practice evidence-based medicine and comply to the process of life-long learning. The importance of educating physicians with an academic mindset is reflected in the adoption of using research as a core competency of a scholar in educational frameworks like the Canadian Medical Education Directives for Specialists (CanMEDS), the U.S. Accreditation Council for Graduate Medical Education (ACGME) and the Dutch National Blueprint for Medical Education.[3-5]

Another defined core competency of a scholar is *conducting research*. Besides all physicians using research, some physicians conducting research are needed as well. Physicians that are involved in both clinical practice and the process of conducting research are called physician-scientists. Physician-scientists have the opportunity to bridge the gap between clinical practice and research, and thereby they are crucial for making advancements within the medical field.[6-9]

The twofold purpose of developing physicians with an academic attitude and stimulating some physicians to pursue a research oriented career starts already during medical education. Involving students in research in medical school is seen as a way to create an academic attitude among students, which underlies practicing evidence-based medicine in future professional practice. By engaging undergraduate students in research, awareness of research could be promoted and could, for instance, contribute to students' ability to critically appraise research performed within their discipline.[10] Therefore, in line with the Boyer Commission's call to promote undergraduate students' engagement in research, many higher education institutes, including medical schools, are aiming to or already started to integrate research-related courses within the core curriculum with the goal to scientifically educate the professionals of the future.[11-13]

However, attempts to involve undergraduate students in formal research during medical training remain inadequate.[11] Most medical schools educate large numbers of medical students at the same time, especially in early phases of medical training. Large scale education on the one hand and individually providing students with authentic research experiences on the other hand is considered not that easy to achieve.[10,14]

There is a pronounced call to transition from research-informed education, in which students are passive consumers of research knowledge, to research-based education, in which students are actually involved in research and thereby actively gathering knowledge. As 'practice makes perfect' it is important to involve students in research as early as possible during medical school.[11]

The question, however, arises how providing a course for large groups of undergraduate students in which they individually conduct research could be established. In what way could such a course with authentic research experiences be feasible? Leiden University Medical Center designed and implemented an obligatory research course for all first-year medical students with authentic hands-on research experiences and the possibility to individually conduct clinical research from start to end within the confines of a course. Drawing on our own experiences, existing literature, and theories we propose twelve tips to design a research course which can be embedded in large scale education and which allows students to individually conduct research.

Tip 1

Provide an experiential opportunity by involving students in every stage of the scientific research process

Learning by doing is believed to be part of 'good education' and the most effective way to master certain skills, like conducting research.[15-17] Students can either be seen as passive audiences or as active participants.[18] Viewing students as active participants is the most optimal way to engage students in activities like research,[19-21] as students could lose curiosity as a result of passive learning approaches.[10,22] Furthermore, practice is important to transfer learned skills from short-term to long-term memory.[23] Therefore, it is of great importance to offer students the opportunity to conduct research themselves. In this way, students are introduced to the field of conducting research and learn how research in their discipline leads to the creation of new knowledge, which methods could be used to reach this goal, and how new knowledge could be distributed into the real world.[10] Previous studies within the medical context have shown that undergraduate students have a narrow perspective of research and that the awareness of the importance of research develops in later phases of medical training.[24-26] By providing students with the opportunity to conduct research already in early phases of medical training, students get acquainted with the broad character of conducting research, which results in a broader perspective of what it entails to conduct research and how research could contribute to patient care.[27]

Tip 2

Provide authentic research experiences with real patient data and opportunities to answer relevant clinical research questions

Engaging students in real-world tasks, i.e. problem-centred learning, increases motivation and as a result promotes learning. One of the requirements to promote deep learning is that learners should not only be engaged at the operational level, but should also acknowledge and experience the relevance of the real-world environment.[28] This underpins the importance of relevant content, showing that an undergraduate research course should not merely focus on the research process but should explicitly take content into account as well.[18] Therefore, it is important to promote authenticity in an undergraduate research course. This contributes to the understanding of the research process, and stimulates curiosity and motivation for research among students.[10,29,30] Authenticity can be increased by providing students with the opportunity to individually collect data from real patients. We acknowledge this may be challenging within large scale education, which is why the next tip will provide a possible solution.

Tip 3

Distribute data collection over all students to make it feasible within a short course

In research with real patients, data collection usually is the most time-consuming part. By giving every student the responsibility to collect a small amount of data within a real-life setting, efforts can then be combined to establish a large dataset. In this way, every student has the opportunity to experience the process of collecting real-world and relevant data without it being too intensive and time-consuming. Furthermore, it gives them access to a larger dataset to answer their research question as well, which also contributes to the relevance of their study. In this way collecting data contributes to their feelings of autonomy and ownership, and is authentic. Moreover, gathering data collectively can stimulate feelings of positive social interdependence and individual accountability.[31] That is, students can feel the need to collect high quality data when their peers depend on this data collection as well. Our case could serve as a valuable example: students are included in a short internship in a nursing home during an earlier course. During this internship, students also collect data on three patients in the nursing home. After three months, students return to the nursing home to collect follow-up data on the same three patients. All data of approximately 350 students is combined in one dataset, resulting in a dataset of about 1000 patients for every student to use during their research project. In this way, every student can compose a unique research question, which can be answered by using the combined larger dataset existing out of data of approximately 1000 patients measured at two timepoints.

Ethical approval is an essential aspect of performing research, but at the same time this could be a major obstacle for designing and implementing authentic undergraduate research projects. In our set-up, we directed the focus of students towards the experience of conducting research individually. Writing their own individual study protocol as well seemed too time-consuming and was not the main purpose of the research course. Furthermore, submitting 300 protocols to the ethical review board was not an option. Therefore, in our case, the educators prepared a single protocol for data collection and students received the instruction to develop their own research question which should be answered with the data according to the developed protocol. The teaching aims of the project were discussed with the ethical review board, who agreed that the research course is mainly a learning experience for students. They approved our educational research project, including data collection and the incidental possibility to write an (educational) scientific publication. We do, however, teach students the ethical aspects of conducting research within clinical practice during lectures.

Tip 4

Stimulate curiosity with relevant clinical examples

Stimulating curiosity among students is of crucial importance in education, as this influences the need to know more and the willingness to learn.[29] Furthermore, curiosity influences motivation for and both involvement and persistence in tasks, for instance research-related activities.[11,15,23,32,33] Curiosity is especially triggered when it touches upon real-world problems and elucidates emotion.[29] Therefore, using relevant clinical examples involving patients seems key in the context of undergraduate medical education as this touches upon the real-world problems medical students will encounter in future professional practice. On top of that, medical educators should also discuss clinical problems that are on the frontiers of science and that have not been solved yet with scientific research. They may express their hypotheses and doubts in this process, in order to demonstrate students that science is ever evolving and fed by curiosity. Curiosity of students is known to flourish within educational contexts that show multiple possible perspectives and allow for openness regarding academic uncertainty.[34] Moreover, making students aware of the academic uncertainty will contribute to their ability to critically appraise scientific literature as students enter the academic world with the tendency to believe everything they read.[10]

Tip 5

Give students autonomy in conducting their own research project

According to the Self-Determination Theory (SDT), a major motivational theory used within multiple disciplines, three basic psychological needs must be fulfilled in order to enhance intrinsic motivation (i.e. doing a certain activity out of pure interest or enjoyment). In turn, intrinsic motivation is related to better overall wellbeing and academic performances. Autonomy is one of the three psychological needs and is therefore seen as very important.[35,36] By stimulating feelings of autonomy, students develop feelings of ownership of their research, which is important to persist in an activity. Autonomy could be provided to students by giving them freedom of choices within their research project and by stimulating them to take a leading role in the implementation of their research. This can be established by providing students with the opportunity to choose a topic and research question they want to answer, to collect data within real-life settings, to individually perform statistical analysis to answer the research question, and to individually present work to peers and researchers.

Tip 6

Provide research experiences to students in large as well as smaller group sessions

Alternating between large and smaller group sessions creates opportunities to capture a large group of students on the one hand, and provide those same students with the possibility to formulate their unique research question and conduct their research individually on the other hand. Necessary information can be provided to students during lectures, which can serve as a platform to demonstrate new knowledge or activate existing knowledge among learners, both of which are believed to be a first step to promote learning.[28] Lectures offer a way to reach large groups of students, providing them with a sufficient research-related foundation to subsequently conduct research individually. For instance, the lectures could not only provide students with a foundation in actually conducting research, it could also serve the purpose to educate students on how to comply to ethical standards surrounding research and scientific integrity. However, according to the other design principles of Merrill, learners should also be actively engaged in solving authentic problems, with the ability to apply the knowledge in a relevant setting.[28] Here, the value of smaller group sessions should be taken into account, in which students develop in-depth knowledge by actually conducting research themselves. Thereby, students are able to apply and integrate skills into real-world activities. The smaller group sessions offer opportunities to comply with the other principles to promote learning, e.g. authenticity and relevance. Furthermore these small group sessions provide possibilities to comply with other needs of students, like enhancing their self-efficacy by offering time to practice while scaffolding the research process.

Tip 7

Use the smaller group sessions to scaffold the research processes

Next to autonomy, SDT identifies 'competence' as one of three required psychological needs. Competence within this theoretical framework can be defined as the feeling of being able to succeed in a certain domain or task.[35,36] This touches Bandura's concept of self-efficacy, which is defined as the belief in one's own capabilities to accomplish an outcome.[37] It is suggested that if one is confident regarding one's own capability in a certain domain, that one is more inclined to pursue that specific direction.[37] This means that if students are more confident about their research capabilities, the chances of continued engagement in research become higher, which is substantiated by previous research findings.[38,39] This underlines the importance of fostering positive self-efficacy beliefs among students during a research course, especially during the undergraduate phase. Most students encounter research processes for the first time during such an undergraduate course, which implies the need to support students in an adequate way to promote their first success experience with research, which in turn is related to enhancing specific self-efficacy beliefs.[37] By dividing students into small groups and assigning teachers with research expertise to these groups, research processes within individual research projects of students can be scaffolded. Within the small group sessions, students have the ability to ask questions regarding their own research project to both the teacher as well as their peers. In this way, students are provided with the possibility to autonomously conduct their individual research while being supported and closely monitored. This not only offers students a desired 'social safety net', but it provides students with the opportunity to ask questions and receive help from more experienced researchers, at the same time serving as inspiring role models.[27]

A practical example is the possibility for students to develop their own research question, which contributes to their feelings of autonomy. However, students are often frightened when first conducting research and posing a research question is one of the hardest parts for students to individually construct. Therefore, it is of great importance to support undergraduate students within this important phase. In most instances, little attention and time is aimed at helping students to learn how to frame a good research question.[10] In our course, students are asked to think about a relevant question for their research before the small group session. Within this particular session, the teacher initiates a brainstorm and discusses what a 'good' research question entails. Subsequently, students are asked to form even smaller groups to talk about each of their independent research questions and to shape these into answerable and relevant research questions (e.g. 'the effect of variable X on variable Y'). As the group sessions are with a small amount of students, the teacher is able to closely monitor students' progress and able to ensure that every student leaves the session with a content feeling and an answerable research question. In turn, this complies with the need for competence and enhances self-efficacy beliefs. For students this contributes to the feeling that they are able to successfully implement their own individual research.

Tip 8

Use inspiring researchers as teachers of the small group sessions

Effective mentoring is believed to be key for successful undergraduate research experiences.[40,41]. Assigning one teacher to one group during all small group sessions fosters continuity and creates a safe environment in which students are stimulated to ask questions. As students are not experienced in conducting research, the need for mentors to be approachable to students is of crucial importance.[42] The teachers should target a 'low threshold' culture, as this could really contribute to students' learning experiences. Posing PhD students and physician-scientists as teachers in these small group sessions not only contributes to a 'low threshold' culture in which difficulties surrounding the research process that students encounter are recognized, but it also offers the possibility to inform students about different facets of conducting research. Furthermore, just in time encouragements of mentors contributes to students' confidence.[42] As PhD students and physician-scientists are involved in research on a daily basis, they are pre-eminently able to guide students through the difficult and sometimes frightening landscape of conducting research. Furthermore, these PhD students and physician-scientists can trigger enthusiasm by telling students about their research in an inspiring and motivating way. Thereby, they can serve as an inspiring role model, which is believed to enhance positive perceptions of and motivation for research among students.[27]

Tip 9

Implement peer discussion within the course

The third psychological need as described by SDT is 'relatedness', the need to have a sense of belonging and connectedness with like-minded others. This sense of belonging and connectedness can be created among students within the small group sessions, whom are all novices when it comes to conducting research. This provides students with feelings of 'not being alone'. Furthermore, by providing students with the possibility to guide each-other and stimulate peer discussion, deep learning of both content and skills is enhanced.[42] Within our course, students can discuss their research with peers during the smaller group sessions (monitored by the teachers). Furthermore, students are asked to provide peer feedback during the presentations as well. By creating a platform in which students help each other, the relatedness among students is promoted. Moreover, by seeing other students succeed in the same complex task, students' self-efficacy beliefs will be enhanced as well. According to the Social Cognitive Theory, the process of 'mastery of experiences' promotes better academic outcomes.[37]

Tip 10

Let students disseminate their work by writing a professional academic piece

Dissemination of scientific work is seen as the last step in the research cycle. As we advocated to involve students in every stage of the research process, it is important to promote dissemination of their work as well. This not only discloses the broad character of conducting research, but it also provides students with the opportunity to show understanding of their own conducted research and the possibility to publicly demonstrate the 'newly learned'.[28] Awareness of the possible avenues to disseminate scientific work will help to create a sense of what it means to be a researcher among students.[42] Furthermore, students are able to practice academic writing and develop a notion of how scientific work could be communicated to the world. This contributes to success experiences and leads to acknowledgment for one's work, which motivates students when it comes to conducting research.[2,27] For educators, this can help to recognize young talent resulting in stimulating students to work towards a real scientific article. In our course, students write an extended abstract of about two pages following the line of an original article (i.e. introduction, methods, results, discussion). As a sequel to the extended abstract students wrote within our course, students can always put effort into writing and submitting a scientific article within a peer-reviewed journal.

Tip 11

Let students orally present or display their final work

Demonstrating new knowledge or skills to others promotes deep learning. Here, it is important to note that learning is especially promoted when learners can discuss or defend their new knowledge.[28] Giving an oral or poster presentation of your work seems to pre-eminently suit this goal. Furthermore, presenting your work contributes to the feelings of ownership surrounding the conducted research project. Moreover, giving presentations is included in the work of a researcher as well and is thereby critical for students if one of the aims is to prepare them for future work.[10,42] Subsequently, students should be encouraged to communicate their research. In our course, the last group session is dedicated to the presentation of students' work, in which all students present their work to peers and the assigned researcher. This session simulates a real conference presentation session. The peers and researcher form a critical and informed audience, which contributes to the recognized importance of students to present high-quality work. Furthermore, students are stimulated to give peer feedback. Thereby, students both learn to give and receive constructive feedback. This also contributes to their ability to critically appraise scientific work of others, a skill that is very important in future professional practice as well.[1] By giving students the opportunity to present their work in front of a critical audience and to receive feedback, students are also able to observe their own progress which is very motivating.[28] Furthermore, in line with the Social Cognitive Theory, preliminary analysis in a study conducted among undergraduate students shows that a success experience in presenting research-related work (defined as receiving positive feedback and a high grade for the presentation in this course) has an effect on positively enhancing both research self-efficacy beliefs as well as motivation for research.[37] This emphasizes the need to provide students with a platform to disseminate their work orally, while creating an environment in which constructive feedback is given by peers.

Tip 12

Include different types of assessment and provide feedback on both the report and presentation

By promoting the dissemination of scientific work both written and orally, students are involved in the last stages of conducting research. These two assignments can be seen as part of the real scholarly world and are authentic in itself. Providing students with feedback on both assignments, reflects some kind of 'stepped preparation' in which the received feedback could help them to prepare for their official exam that is part of the course as well. It is important to include the written and oral dissemination of the research in the assessment criteria next to the official exam. In this way, assessing students meets the requirements of higher educational institutes but includes authentic assessment measures as well.

Conclusion

Designing and implementing a course for large groups of undergraduate students in which they still conduct research individually can be a challenging experience, due to the large numbers of students and possible difficulties in integrating authentic, real-world aspects. By including different modes of teaching throughout the course and by combining student forces to make data collection on this scale feasible, such a course for large groups could be established. By stimulating students to become producers instead of passive consumers of knowledge, deep learning is promoted and motivation is awakened, which is a first step to develop future physicians with an academic attitude.

References

1. Dekker FW. Science Education in Medical Curriculum: Teaching Science or Training Scientists? *Medical Science Educator*. 2011;21:258-260.
2. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
3. Swing SR. The ACGME outcome project: retrospective and prospective. *Medical Teacher*. 2007;29(7):648-654.
4. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009*. Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.
5. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report*. Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.
6. DeLuca GC, Ovseiko PV, Buchan AM. Personalized medical education: Reappraising clinician-scientist training. *Science translational medicine*. 2016;8(321):321fs-322fs.
7. Ommering BWC, Dekker FW. Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education*. 2017;6(6):366–368.
8. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine*. 2017;65(5):942-948.
9. Sklar DP. We Must Not Let Clinician-Scientists Become an Endangered Species. *Academic Medicine*. 2017;92(10):1359-1361.
10. Walkington H, Griffin AL, Keys-Mathews L, et al. Embedding Research-Based Learning Early in the Undergraduate Geography Curriculum. *Journal of Geography in Higher Education*. 2011;35(3):315-330.
11. Abu-Zaid A, Alkattan K. Integration of scientific research training into undergraduate medical education: a reminder call. *Medical Education Online*. 2013;18.
12. Scager K, Akkerman SF, Pilot A, Wubbels T. Challenging high-ability students. *Studies in Higher Education*. 2014;39(4):659-679.
13. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education*. 2017;6(4):216-226.
14. Kindon S, Elwood S. Introduction: More than MethodsReflections on Participatory Action Research in Geographic Teaching, Learning and Research. *Journal of Geography in Higher Education*. 2009;33(1):19-32.
15. de Jong PGM, Haramati A. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching*. Dordrecht: Springer Science + Business Media; 2014.
16. Vereijken MW, Kruidering-Hall M, de Jong PG, de Beaufort AJ, Dekker FW. Scientific education early in the curriculum using a constructivist approach on learning. *Perspectives on Medical Education*. 2013;2(4):209-215.
17. Chickering AW, Gamson ZF. Seven principles for good practice in undergraduate education. *AAHE bulletin*. 1987;3:7.
18. Healey M, Jordan F, Pell B, Short C. The research-teaching nexus: a case study of students' awareness, experiences and perceptions of research. *Innovations in Education and Teaching International*. 2010;47(2):235-246.
19. Janmaat VT, Kortekaas KE, Moerland TM, et al. Tutored Learning: An Effective Way for Students to Benefit Research by Critical Appraisal. *Medical Science Educator*. 2013;2(23):269-277.

20. Jenkins A, Breen R, Lindsay R, et al. *Reshaping teaching in higher education: Linking teaching with research*. London: Kogan Page Limited; 2003.
21. Lazonder AW, Harmsen R. Meta-Analysis of Inquiry-Based Learning: Effects of Guidance. *Review of Educational Research*. 2016;86(3):681-718.
22. Scheyvens R, Griffin AL, Jocoy CL, Liu Y, Bradford M. Experimenting with active learning in geography: Dispelling the myths that perpetuate resistance. *Journal of Geography in Higher Education*. 2008;32(1):51-69.
23. Lucariello JM, Nastasi BK, Anderman EM, Dwyer C, Ormiston H, Skiba R. Science Supports Education: The Behavioral Research Base for Psychology's Top 20 Principles for Enhancing Teaching and Learning. *Mind, Brain, and Education*. 2016;10(1):55-67.
24. Murdoch-Eaton D, Drewery S, Elton S, et al. What do medical students understand by research and research skills? Identifying research opportunities within undergraduate projects. *Medical Teacher*. 2010;32(3):e152-e160.
25. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15(1):95.
26. Imafuku R, Saiki T, Kawakami C, Suzuki Y. How do students' perceptions of research and approaches to learning change in undergraduate research? *International journal of medical education*. 2015;6:47-55.
27. Ommering BWC, Wijnen-Meijer M, Dolmans DHJM, Dekker FW, Van Blankenstein FM. Promoting positive perceptions of and motivation for research among undergraduate students to stimulate future research involvement: a grounded theory study. *BMC Medical Education*. 2020;20(1):204.
28. Merrill MD. First principles of instruction. *Educational Technology Research and Development*. 2002;50(3):43-59.
29. Prober CG, Heath C. Lecture Halls without Lectures - A Proposal for Medical Education. *The New England Journal of Medicine*. 2012;366(18):1657-1659.
30. Panelli R, Welch RV. Teaching research through field studies: A cumulative opportunity for teaching methodology to human geography undergraduates. *Journal of Geography in Higher Education*. 2005;29(2):255-277.
31. Johnson DW. Social interdependence: Interrelationships among theory, research, and practice. *American Psychologist*. 2003;58(11):934-945.
32. Willison J, O'Regan K. Commonly known, commonly not known, totally unknown: a framework for students becoming researchers. *Higher Education Research & Development*. 2007;26(4):393-409.
33. Ommering BWC, van Blankenstein FM, Waaijer CJF, Dekker FW. Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education*. 2018;7:248-255.
34. Dyche L, Epstein RM. Curiosity and medical education. *Medical Education*. 2011;45(7):663-668.
35. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
36. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. New York City: Guilford Publications; 2017.
37. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
38. Robnett RD, Chemers MM, Zurbriggen EL. Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. *Journal of Researcg in Science Teaching*. 2015;52(6):847-867.

39. Bierer SB, Prayson RA, Dannefer EF. Association of research self-efficacy with medical student career interests, specialization, and scholarship: a case study. *Advances in health sciences education: theory and practice.* 2015;20(2):339-354.

40. Linn MC, Palmer E, Baranger A, Gerard E, Stone E. Undergraduate research experiences: Impacts and opportunities. *Science.* 2015;347(6222).

41. Jones RM, Davis SN. Assessing faculty perspectives on undergraduate research: Implications from studies of two faculties. *CUR Quarterly.* 2014;34:37-42.

42. Shanahan JO, Ackley-Holbrook E, Hall E, Stewart K, Walkington H. Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature. *Mentor Tutor.* 2015;23(5):359-376.

13

General discussion

General aim

Physicians both involved in clinical duties as well as conducting research (i.e. physician-scientists) are needed to make advancements within the medical field by connecting bedside and bench. Medical education plays an important role in delivering graduates that comply to the 'scholar' role as proposed by the CanMEDS framework, resulting in physicians that are able to both use research in order to practice evidence-informed decision making as well as conduct research. As a current physician-scientist shortage is apparent worldwide, research focuses have shifted towards investigating the role medical training could play to counteract the physician-scientist decline.

Following the need to identify *how* medical training could contribute to developing future physician-scientists, and the current gaps within our knowledge, the general aim of this thesis was to provide insights into the impact early phases of medical training may have on cultivating physician-scientists, by elaborating on the role of motivation for research and extracurricular research programmes. More insights into how intrinsic motivation for research could be promoted early on in medical school helps to determine possibilities for interventions and the implementation of evidence-based strategies, both intra- and extracurricular, to enhance intrinsic motivation for as well as involvement in research among medical students. As previous research showed that involvement in research during medical training is related to further research involvement during professional practice,[1-3] we believe that first steps to foster the physician-scientist workforce of the future could be made as early as undergraduate medical training.

In this chapter, a brief overview of the main findings will be provided. Thereafter, the main findings of the studies will be combined to draw general conclusions on 1) the importance of early awareness and intrinsic motivation for research, 2) ways to stimulate intrinsic motivation for research according to existing theoretical perspectives and our research findings, 3) the role of opportunities such as extracurricular research programmes within medical training, and 4) intrinsic versus extrinsic motivation for research. Furthermore, strengths and limitations of this thesis are considered. To conclude, both implications for future research as well as practice will be elaborated on.

Box 1. Overview of research questions or topics within this thesis

Chapter 2

- To what extent are first-year medical students intrinsically and/or extrinsically motivated for research?
- What influence do self-efficacy, perceptions of research, curiosity, and need for challenge have on intrinsic and extrinsic motivation for research?

Chapter 3

- How do first-year medical students perceive research?
- Which factors contribute to motivation or demotivation for conducting research?

Chapter 4

- What is the effect of motivation for research on actual research involvement?

Chapter 5

- What is the influence of a success experience within an obligatory research course on motivation for research and research self-efficacy?
- Is the effect of a success experience different for standard (i.e. written exam) versus more authentic (i.e. report and oral presentation) assessments?

Chapter 6

- Are medical students who publish before graduation more likely to publish after graduation, do they publish a greater number of papers after graduation, and do they publish papers with a higher citation impact after graduation?

Chapter 7

- Elaboration on medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency

Chapter 8

- Describing an extracurricular Honours programme to engage future physicians into scientific research in early stages of medical training

Chapter 9

- What is the effect of students' first-year academic performance on academic success within an extracurricular research programme, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity?

Chapter 10

- What is the effect of an extracurricular research programme on academic achievement, intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity?

Chapter 11

- How does engaging in authentic research at undergraduate level contribute to student wellbeing?

Chapter 12

- Connecting research to practice: Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students

Overview of main findings

In our first study **(Chapter 2)**, we identified first-year medical students' intrinsic and extrinsic motivation for research. Students were surveyed within the first three months of medical training and findings suggested that first-year medical students are already motivated to conduct research, as they score relatively highly on both intrinsic and extrinsic motivation for research. Self-efficacy beliefs, perceptions of research, curiosity, and need for challenge were all positively associated with intrinsic and extrinsic motivation for research, also after adjusting for gender and age. These constructs together explained 40% of the variance in intrinsic motivation for research, while only explaining 14% of the variance in extrinsic motivation for research. Thereafter, we focused on perceptions of and motivation for research by using a grounded theory approach **(Chapter 3)**, showing that first-year medical students differed greatly in their perceptions of and motivation for research, but did already have a broad perspective of what conducting research entails. Furthermore, our results suggested a relation between perceptions of and motivation for research. Our findings were in line with the Self-Determination Theory (SDT), implying that autonomy, relatedness, and competence influenced motivation for research. Relevance, need for challenge, curiosity, and inspiring role models were also identified as positively influencing motivation for research. Our following study showed that it was mainly intrinsic motivation for research that played an important role for students in acting upon one's intentions **(Chapter 4)**, as intrinsic motivation for research at the start of medical training had a strong effect on research involvement in the second year of medical training, also after adjusting for gender, age, extracurricular high school activities, self-efficacy beliefs, perceptions of research, and curiosity. Extrinsic motivation for research, however, did not contribute on top of intrinsic motivation for research. Further investigations revealed that an academic success experience in a research-related course, operationalised as student grades on two authentic (i.e. written report and oral presentation) and one less authentic (i.e. written exam) assessment, contributed to higher levels of intrinsic motivation for research and research self-efficacy beliefs **(Chapter 5)**. Our findings suggested that authentic assessment is important – after adjusting for motivational baseline scores, age, gender, and grade point average (GPA) of the first four months, only a success experience in orally presenting one's research was related to an increase in both intrinsic motivation for research and research self-efficacy beliefs. Our following study, expanding the success experience perspective by perceiving research publications as a form of experiencing research success, showed that medical students who had published before graduation were more likely to publish after graduation, published more papers, and had a slightly higher citation impact after graduation **(Chapter 6)**. From our studies, it seems that mainly intrinsic motivation for research should be targeted. However, we do think it is important to acknowledge the possibility that extrinsically motivated students can become intrinsically motivated for research along the way **(Chapter 7)**, after being exposed to research experiences. Besides exposing students to research within the core curriculum, an extracurricular research programme (e.g. research-based Honours programme) could be implemented as well **(Chapter 8)**. Our studies showed that, if the pre-eminent goal of extracurricular research programmes is to cultivate future physician-scientists, selection should take motivation into account. Students starting the extracurricular research programme with a first-year GPA <7 did have higher odds for drop-out from the extracurricular research programme, but were not inferior to students starting the programme with a first-year GPA ≥7 on intrinsic motivation for research, perceptions of research, and curiosity in the third year of medical training – which are all constructs related to research involvement **(Chapter 9)**. When it comes to identifying actual effects of the extracurricular research programme, our findings suggest that participation only affected levels of intrinsic motivation for research **(Chapter 10)**. To conclude, we tried to connect our research to both theory and practice, by 1) expanding our theoretical view on the Self-Determination Theory by including an authenticity framework to shape undergraduate research experiences and promote student wellbeing **(Chapter 11)**, and 2) proposing twelve tips to offer students the experience to conduct research individually as part of the core curriculum, with authenticity as an important component in designing such a course **(Chapter 12)**.

General conclusions

The importance of early awareness and intrinsic motivation for research

"Future physician-scientists: let's catch them young" – the title of this thesis and general aim to provide insights into the impact early phases of medical training could have on developing future physician-scientists, implies that the next generation of physician-scientists could be targeted early on in medical training. In order to stimulate undergraduate students to acknowledge the possibility for a physician-scientist career and subsequently pursue this career path, our studies, taken together, suggest that three overarching topics play an important role: awareness, motivation, and opportunity.

Ten Cate and colleagues suggested that students entering medical school are investing to become a physician and work with patients.[4] This implies that students in early phases of medical training would be particularly interested in becoming a physician, without focusing on the importance of research for medical practice. This perspective is corroborated by Rosenkranz and colleagues[5], describing that medical students only understood the real relevance of research for practice, and thus patients, after they experienced uncertainties in practice during the later clinical phases of medical training. The question that arises, challenging our statement in the title of this thesis, is whether beginning medical students are aware of the importance of research for practice and patients, and are motivated for research parallel to starting medical training to become a physician. In other words, this raises the question if we could indeed "catch students young" in order to foster the physician-scientist workforce? After having read this thesis, I hope that the broad readership agrees that opportunities to take first steps in developing future physician-scientists during early phases of medical training indeed exist.

When it comes to awareness, our findings suggested that first-year students already perceived research as important for medical practice and patients **(Chapter 3)**. Students elaborated on research as a means to make progress in science and healthcare, develop and improve medicines and illness treatments, educate and create better physicians, and improve patient experience and trust. It was the importance of research for medical practice and patients that was a major motivating factor to conduct research as well. Placing these findings in a broader and more general perspective, it is noteworthy to state that medical students in the Netherlands start medical training right after graduating from high-school with a mean age of about 18-20 years and in most of the cases no prior research experience.[6,7] Yet, they still seem to already have a correct and valuable view on the importance of research for clinical practice. Imafuku and colleagues conducted a study among third-year medical students, interviewing these students before and after a research experience.[8] The authors concluded that the research experience helped to broaden students' perceptions of research. This helps to clarify the awareness among our students regarding the importance of research for practice, as our students followed a course halfway during their first year in which they conducted research individually and in which research was explicitly connected to practice, as students formulated a research question based on bedside experiences within a nursing home and collected data from real patients **(Chapter 12)**. This somewhat contradicts the findings of Rosenkranz and colleagues, arguing that medical students should experience uncertainties in practice in order to understand the real relevance of research for practice.[5] Indeed, this could be perceived as one way in which research and practice are explicitly linked to one another, resulting in uncovering the impact research may have on patient care. However, our results suggest that students in earlier stages of medical training could be targeted as well, for instance by providing them with authentic research experiences in the first year of medical training already.

Furthermore, with regard to motivation for research, our findings suggested that students are already both intrinsically and extrinsically motivated for research when entering medical school without having any prior research-related experiences **(Chapter 2)**. Students not only seem to be motivated to become a physician, but are motivated for research as well, providing an opening to target young students. Identifying their high levels of motivation for research helps medical educators to recognize that students enter medical training motivated for research, and that learning environments can be created in such ways that these levels of motivation are fostered. This could contribute to the two-fold purpose of medical training – in line with two of the core competencies of the CanMEDs – to deliver graduates with an academic mindset to practice evidence-informed decision making, as well as stimulating some graduates to pursue a research oriented career. When focusing on the latter, our studies do suggest that intrinsic motivation for research in particular should be targeted when promoting actual research engagement among medical students **(Chapter 4)**. This is in line with the SDT, which proposes that intrinsic motivation is of better quality, as it is associated with better academic performance and general wellbeing.[9,10] Our findings corroborate SDT's vision that motivation is not one single construct, but rather consists of different types of motivation (e.g. intrinsic versus extrinsic in nature), and contributes to expanding the applicability of this theory to the medical education context and motivation specifically for research. Additionally, Ranieri and colleagues conducted a review study within the medical domain, suggesting that it is indeed intrinsic motivation that is important among medical professionals for career persistence and progression in academic medicine.[11]

The findings from this thesis thus imply that motivation for research plays an important role. However, in unravelling the role of motivation for research it turned out that focus should be directed towards intrinsic motivation for research, as our study showed that especially intrinsic motivation for research is related to actual research engagement during medical training **(Chapter 4)**. In turn, being involved in research during medical training is related to research involvement in future professional practice.[1,2] This is substantiated by one of our studies, showing that medical students who published before graduation were more likely to be actively involved in research after graduation **(Chapter 6)**. In sum, as intrinsic motivation for research is related to research involvement during medical training, which in turn is related to research involvement during professional practice, we believe that when aiming to 'catch students young' for a physician-scientist career, intrinsic motivation for research is key. This means that efforts could be directed towards identifying already intrinsically motivated individuals and fostering their intrinsic motivation levels as well as implementing evidence-based strategies to promote students' intrinsic motivation for research during early phases of medical training.

Ways to stimulate intrinsic motivation for research

This thesis offers some insights into how intrinsic motivation for research could be stimulated among undergraduate medical students. Within our studies, multiple constructs emerged and were examined on their relationship with intrinsic motivation for research. Our cross-sectional study at the beginning of medical training revealed that in particular research self-efficacy beliefs, perceptions of research, interest curiosity, and need for challenge were important in explaining the variance in intrinsic motivation for research **(Chapter 2)**. As will be discussed below, other studies within this thesis, including research designs going beyond the cross-sectional nature of our second chapter, align with the suggested importance of research self-efficacy beliefs, perceptions of research, curiosity, and need for challenge **(Chapters 3, 5, 11)**.

Research self-efficacy beliefs, i.e. one's belief in his or her own ability to accomplish a task[12], which is believed to be somewhat similar to SDT's need for competence, emerged as a theme in our qualitative study as well **(Chapter 3)**. Targeting students' research self-efficacy beliefs could thus be seen as a way to stimulate intrinsic motivation for research. This is in line with the Social Cognitive Theory (SCT), stating that, in general, increased self-efficacy beliefs are related to increased levels of motivation. According to SCT, self-efficacy can be developed or increased by mastery of experiences (e.g.

successfully achieving a task), social modelling (e.g. seeing a near-peer accomplish similar tasks), improving physical and emotional states (e.g. ensuring the student is relaxed prior to starting a task), and/or verbal persuasion (e.g. verbally encouraging a student). SCT, however, does not distinguish type of motivation and focuses on quantity of motivation rather than quality of motivation. As one of our studies, and multiple other studies within other domains and target populations, did corroborate SDT's vision that quality of motivation matters in order to reach desired outcomes **(Chapter 4)**, we believed that it is valuable to make this distinction. When testing Bandura's hypothesis in our specific context, we therefore investigated the effect of an academic success experience on research self-efficacy beliefs and specifically intrinsic motivation for research **(Chapter 5)**. This hypothesis builds on SCT's notion that mastery of an experience, or experiencing success in fulfilling a task, relates to research self-efficacy and intrinsic motivation for research. Our study revealed that an academic success experience in presenting research not only increased research self-efficacy beliefs, but also affected intrinsic motivation for research directly, with a higher grade for the oral presentation being related to higher levels of intrinsic research motivation. Thereby our study underpins the importance of authentic assessment methods. We believe that not only the grade (i.e. the proxy for a success experience within our study) itself contributed to feelings of success, but that direct constructive feedback on the presentation is important as well. Certainly as we did not find an equal, positive effect for a success experience within writing a research report, which could also be seen as an authentic assessment method. This is in line with the design principles as proposed by Merrill, stating that learning and motivation is especially promoted when students can discuss their gained knowledge and are able to observe their own progress.[13] Orally presenting research in front of a critical audience and receiving feedback suits these goals. In our particular course, students received delayed feedback on the research report after about two weeks – lacking the opportunity for feedback dialogue, which might impact students' feedback uptake and subsequent self-perceived learning outcomes.[14] This is also in line with the Social Cognitive Career Theory (SCCT), building on SCT for a large extent and proposing that social interactions are not only important for strengthening self-efficacy beliefs but outcome expectations as well. In turn, these outcome expectations are believed to be directly related to action and, as discussed by Bakken and colleagues, could impact the choice to pursue a physician-scientist career.[15] Thus, this theoretical perspective contributes to the idea that first steps could be made early on in medical training as well. To conclude, intrinsic motivation for research could be enhanced by targeting research self-efficacy beliefs or directly stimulating success experiences within research, although authentic assessment with the opportunity for feedback dialogue seems to be of crucial importance.

The important role of authenticity was also emphasized when connecting our research to theory **(Chapter 11)** and practice **(Chapter 12)**. According to Wald and Harland, authentic research experiences can be accomplished in three ways: 1) authenticity as relating to the real world, 2) the existential authentic self, and 3) a degree of personal meaning.[16] Authenticity as relating to the real world refers to learning that mirrors the real-world. From this perspective, reporting and orally presenting one's own research **(Chapter 5)** could be perceived as authentic. The existential authentic self relates to developing self-identity and feelings of ownership are emphasized in order to become an independent learner. At the same time, receiving expert support from teachers is imperative as well. Lastly, a personal degree of meaning is seen as a necessity in order to perceive something as authentic. This sense of meaning depends on what students deem important on a personal level, while created between and shared with others. When looking at this framework through the lens of SDT, similarities emerge with the three psychological needs that are a requirement for enhancing intrinsic motivation **(Chapter 11)**. Feelings of ownership are aligned with the need for autonomy. Thus, promoting feelings of ownership and providing students with opportunities to work independently when designing opportunities for students to conduct research is important to foster or enhance intrinsic motivation for research **(Chapter 3, 11, 12)**. Feelings of social connectedness, i.e. creating a sense of meaning between and shared with others, mirror the need for relatedness. Initiatives to socially connect both student-mentor as well as student-student can thus be seen as important to stimulate intrinsic motivation for research **(Chapter 11, 12)**. Within our qualitative study, students mentioned that this could be established by, for instance, collaboration and network opportunities **(Chapter 3)**. They also mentioned, however, that support of an expert mentor is of crucial importance as well, which is in line with the vision that teachers providing expert instructions are needed **(Chapter 12)**. In turn, from a theoretical perspective, this could be linked to SDT's proposed need for competence **(Chapter 11)**. To summarize, by imbedding authentic elements when shaping undergraduate research learning environments, while being aware of the psychological needs as proposed by SDT, students' intrinsic motivation for research could be promoted **(Chapter 3, 12)**. Furthermore, by extension, this could also foster students' feelings of wellbeing **(Chapter 11)**.

This thesis also suggests that perceptions of research play an important role in promoting intrinsic motivation for research. Our first study revealed that perceptions of research were very important in promoting intrinsic motivation for research **(Chapter 2)**. However, this study did not offer in-depth insights in these perceptions of research among first-year medical students. Therefore, a qualitative grounded theory study was conducted **(Chapter 3)**, which offers an example of a way in which quantitative and qualitative measures depend and build on each other. The findings from this study did not only suggest the broad perspective and levels of awareness our first-year students already had, but suggested a relationship between perceptions of and motivation for research as well. Although this notion emerged from our data, this finding is substantiated by another theory, namely the Theory of Planned Behaviour (TPB). TPB proposes that attitudes are prerequisites for motivation, which in turn is related to showing certain behaviour. Attitudes as mentioned within TPB are defined as perceptions of certain behaviour including designating a favourable versus unfavourable evaluation to that particular behaviour.[17] As this was also the case within our study, this lends support for the influence of perceptions of research on intrinsic motivation for research. Previous studies showed that student perceptions of research are open to change,[8,18] which offers opportunities to target and adjust unrealistic research perceptions, as well as promote positive perceptions of research, and in turn influence intrinsic motivation for research.

Findings of our first study on the importance of curiosity and need for challenge in promoting intrinsic motivation for research (**Chapter 2**), were corroborated by our qualitative findings as well, in which students labelled curiosity and need for challenge as important motivating factors **(Chapter 3)**. Whereas our second chapter focused on type of curiosity, distinguishing interest curiosity (i.e. the satisfaction in discovering new ideas) from deprivation curiosity (i.e. the effort spent on finding solutions to a problem),[19,20] our subsequent chapters focused on epistemic curiosity in general – consisting out of both interest and deprivation curiosity, as both types of curiosity play a role within medical training.[20] These findings underpin the importance of creating learning environments to foster curiosity, for instance by stimulating students to ask questions and actively include students in answering questions and finding answers to problems, as it is also important to emphasize gaps in knowledge to stimulate inquiry.[21] Using relevant clinical examples, questions, and problems could also trigger curiosity **(Chapter 12)**. Furthermore, students with a need for extra challenge should be identified, as this need could be fulfilled by conducting research.

Lastly, going beyond the emphasis within our other studies, our grounded theory approach revealed the importance of relevance for practice and inspiring role models in order to become intrinsically motivated as well **(Chapter 3)**. Relevance aligns with the personal meaning aspect within the authenticity framework as discussed above **(Chapter 11)**, once again underpinning the importance of raising students' awareness of the importance of research for practice and patients. The inspiring role model perspective is substantiated within the review of Bakken and colleagues, discussing practical implications deriving from SCCT in order to stimulate clinical careers, in which the importance of exposing students to successful role models integrating research and practice is emphasized.[15] Shanahan and colleagues underlined the importance of role models and mentorship, by describing ten salient practices of undergraduate research mentors, for instance by dedicating time to one-on-one mentoring and building communities consisting of graduate students, postdoctoral researchers, and other research team members among groups of undergraduate researchers.[22] The latter salient practice could, in turn, expand the number and type of role models for undergraduates as well.

To conclude, different constructs emerged from this thesis and were mentioned as important for stimulating intrinsic motivation for research (i.e. research self-efficacy beliefs, academic success experiences, authenticity, autonomy, relatedness, competence, perceptions of research, curiosity, need for challenge, relevance, inspiring role models), substantiated by different theoretical perspectives (i.e. SDT, SCT, SCCT, Wald and Harland's authenticity framework, TPB) and previous research. As I can imagine that some aspects might be somewhat abstract, practical implications are considered at the end of this chapter.

The role of opportunities such as extracurricular research programmes

As I mentioned at the beginning of the general conclusions section, our studies altogether suggest three important topics that are at play when promoting physician-scientist careers among undergraduate medical students: awareness, motivation, and opportunity. Awareness and motivation are discussed in-depth, which leaves us with opportunity. In part, opportunities linked to the core curriculum have already been described **(Chapter 2, 3, 5, 6, 11, 12)**. However, extracurricular initiatives are designed and implemented worldwide to contribute to fostering future physician-scientists as well.[2,23-26] In line with SDT and the above-discussed perspective, one would particularly aim to enhance intrinsic motivation for research with certain extracurricular research programmes, in order to set the scene and take first steps within the physician-scientist career pipeline. Furthermore, research self-efficacy beliefs, perceptions of research, and curiosity are key in enhancing intrinsic motivation for research and/or research involvement **(Chapter 2, 3, 5, 6, 11, 12)**.

Historically, high-achieving medical students are usually targeted for such extracurricular research programmes. When it comes to perceiving extracurricular research programmes as a means to cultivate future physician-scientists, however, the question arises if targeting only high-achieving students is the right approach. Especially when it is taken into account that 1) grades seem to lack predictive validity for knowledge application and higher order cognitive skills,[27] 2) grades do not necessarily reflect all the competencies valued for healthcare professionals in practice, who should be able to take on different roles, e.g. a communicator, collaborator or scholar,[28] and 3) medical students invest a great amount of academic effort in order to enter medical school and are already selected based on, among others, cognitive abilities,[6] it seems questionable to focus solely on grades. Leiden University Medical Center implemented an extracurricular research programme, mainly based on self-selection and inviting every interested student to participate **(Chapter 8)**. Therefore, we had the unique opportunity to compare two types of students within an extracurricular research programme: the traditionally high-achieving student and the out-of-the-box somewhat lower (i.e. above-average) achieving student. Our results suggested that students within the extracurricular research programme with a first-year GPA below 7 on a 10-point grading system were not inferior to the traditionally high-achieving (i.e. first-year GPA of above 7) students on intrinsic motivation for research, perceptions of research, and curiosity **(Chapter 9)**. This finding suggests that when selecting students for extracurricular research programmes targeting the development of physician-scientists, selection should not be solely based on grades, but should focus on selecting above-average performing students motivated to conduct research and develop within this field of expertise. This implies that, when aiming to get ‘the right person’ into the physician-scientist pipeline, one should make certain extracurricular research programmes more widely accessible. This does, however, raise the question if these programmes, in general, contribute to the broader aim to function as a beginning step in the physician-scientist career pipeline. In other words, what is the effect of an extracurricular research programme on stimulating future research engagement?

Initiatives to map the effects of such extracurricular programmes are apparent, however, gaps in the literature can be identified as the performed studies lack rigorous study designs. Most studies 1) are conducted in retrospect, 2) lack a longitudinal design, and 3) lack a *comparable* control group.[23,29] This, among other things, raises the question if students would have developed in similar ways independently of the extracurricular programme. In order to really map the effects of an extracurricular research programme, one would ideally use an experimental design, randomly assigning *interested* students into participation or non-participation. However, as this is not feasible in practice, simulating a randomized controlled trial might be the best option. Therefore, we used a longitudinal, prospective design in which we compared students participating within the extracurricular research programme to students who showed interest in the programme, but eventually decided not to participate **(Chapter 10)**. Our findings revealed that extracurricular research programme participation increased the odds of obtaining a bachelor degree in time and increased levels of intrinsic motivation for research. In line with Kool and colleagues, we believe that our post-measures might have been too short-term to find effects after 18 months of programme participation regarding research self-efficacy beliefs, perceptions of research, and curiosity.[29] However, we are enthused by the finding that intrinsic motivation for research is enhanced as a result of participating within the extracurricular research programme, which is a key construct in stimulating research involvement during medical training **(Chapter 4)**, and subsequent research involvement during professional practice **(Chapter 6)**.[1] Although further research is warranted, it seems fair to assume that extracurricular research programmes affect intrinsic motivation for research and could be perceived as having an impact within undergraduate phases of medical training when the aim is to take first steps to catch students young and cultivate future physician-scientists, with the suggestion to make these programmes more widely accessible to motivated medical students.

Intrinsic versus extrinsic motivation for research

Within this general discussion, I hope to have shed light on the possibilities to catch future physician-scientists young, i.e. in early stages of medical training. Within this chapter, as a result of theoretical insights and research findings within this thesis, I focused on and emphasized the importance of intrinsic motivation for research. I do feel the need, however, to explicitly mention that this should not be perceived in such a way that extrinsic motivation is by definition labelled as 'bad'. Indeed, intrinsic motivation for research is mentioned to have better quality as it is related to desirable outcomes. Nonetheless, as we also discussed within one of our chapters within this thesis, extrinsic motivation for research might turn into intrinsic motivation for research along the way **(Chapter 7)**. According to SDT, one can shift on the motivation continuum and a process of internalization could take place. This corroborates the idea that extrinsic motivation could indeed turn into intrinsic motivation – though vice versa might be the case as well, which again underlines the need to also foster intrinsic motivation among students. Furthermore, SDT states that certain extrinsic incentives might increase levels of intrinsic motivation for research. Perhaps our study on success experiences offers a good example of how an extrinsic incentive (i.e. an academic success experience operationalised as grades) contributes to advancing levels of intrinsic motivation for research among students **(Chapter 5)**. Furthermore, a publication could be deemed as contributing to one's personal development, but could also be seen as an external reward, which has been proven to be related to increased research involvement as well **(Chapter 6)**. However, future research investigating if and how undergraduate medical students shift on the extrinsic versus intrinsic motivation continuum is needed. To conclude, the key message within this paragraph is that extrinsically motivated students should not be 'written off' as their extrinsic motivation could turn into intrinsic motivation – in other words, the recommendations provided as a result of this thesis might apply to every student in order to get more intrinsically motivated students for research on a career path towards a future as a physician-scientist.

Strengths and limitations

This thesis comes with some limitations. First, all of the research is conducted within one institute, which might impact generalizability. However, the educational programme is based on the Dutch National Blueprint for Medical Education, which is derived from the CanMEDS.[28,30] Therefore, some implications deriving from our research might be translated to other educational contexts. Furthermore, many medical schools provide students with undergraduate research experiences. Although the way medical schools shape these experiences may depend on national (i.e. school system) and local (i.e. medical school) context, we do believe that research skills are generic skills that can be trained in various stages of medical school. For the broader, international readership it also seems noteworthy to mention that, in line with other educational programmes within the Netherlands, our cohort consisted of a largely female population with participants of young age. However, by connecting our findings to broader theories on a regular basis, we hope to have increased the chance of serving other educational areas.

Second, within this thesis, the choice was made to divide type of motivation into intrinsic and extrinsic motivation for research. As also discussed within the general introduction, in order to stimulate undergraduate medical students to pursue a physician-scientist career, it seems to be important that students conduct research because of the spontaneous satisfaction they derive from the activity itself. In other words, they should actually enjoy conducting research and not only value it for professional practice but should also be invested in staying engaged. When it comes to intrinsic motivation, someone's behaviour is fully self-directed.[10] Based on our interpretation of the SDT, own experiences, previous research, and the aim to connect our findings to practice, we chose to deploy the SDT at the level of distinguishing intrinsic and extrinsic motivation for research. We do acknowledge that for theory refining purposes another way to distinguish types of motivation, i.e. autonomous versus controlled motivation, would have been interesting as well. Future research could build on the findings from this thesis and focus on investigating if the same effects occur when applying SDT's autonomous versus controlled motivation distinction.

Third, we mainly focused on short-term measures of research engagement. However, within one study we also investigated long-term outcomes. Although the majority of our studies focused on short-term measures of research engagement, existing theories and previous studies did indicate that these constructs are related to long-term engagement and scholarly output.[1,2] Therefore, we believe we have provided insight into how undergraduate medical students could be targeted aiming to take first steps to foster the future physician-scientist workforce.

Lastly, the majority of our studies relied on self-report in which social desirability might have played a role. However, we did guarantee anonymity for our participants. Furthermore, within our fifth chapter we also included a direct measure of research success. Additionally, within this thesis we had multiple measurements within a longitudinal, prospective design, while using both quantitative and qualitative measures, which is why we hope that altogether this thesis sheds lights on different facets of the important role intrinsic motivation for research could play in stimulating students to pursue a research oriented career.

Future research avenues

Building on the research within this thesis, multiple future research avenues can be identified, a few of which will be shortly discussed below. First, it would be interesting to conduct our studies within other international and/or educational contexts. Second, it would be of great value to examine, both quantitatively and qualitatively, the development of medical students' intrinsic motivation for research during medical training, in which they gradually engage in clinical practice. Third, in line with SDT's vision of a continuum, a valuable future research avenue would be to investigate whether extrinsic motivation for research could indeed turn into intrinsic motivation for research. Fourth, qualitatively exploring students' perceptions of success experiences within a research-related course and how these perceptions influence their intentions to conduct research in the future would be a great addition on top of our fifth chapter investigating the effect of an academic success experience on intrinsic motivation for research by using a quantitative approach. In addition, within this same specific topic, it would be intriguing to study if the same effect of a success experience with authentic assessment methods is found in other research-related initiatives, while focusing at the importance of feedback dialogue as well. Fifth, future research could focus on distinguishing autonomous versus controlled motivation when unravelling the role of motivation for research in order to develop physician-scientists. Sixth, further research into the effects of extracurricular research programmes, both short- and long-term, is warranted. In particular, research focus might be directed towards how research self-efficacy beliefs, perceptions of research, and curiosity could be enhanced as a result of an extracurricular research programme as well. Lastly, the question arises if the pipeline we claim to start building within the bachelor phase of medical training is continued within later phases of medical training, in which focus shifts towards clinical rotations and directly working with patients. Investigating this could also help to shed light on connecting bedside to bench: in what way are clinical questions and problems identified and used as input for research?

Practical implications

Within this thesis, importance and emphasis has been given to educational research on the one hand, and practice on the other hand. At multiple points I have discussed and elaborated on connecting research to clinical practice. In line with that vision, it seems of crucial importance to connect the research conducted within this thesis to educational practice as well. Therefore, within this paragraph, practical implications derived from our research findings are considered.

Practical implications can be discussed at two levels: 1) what could be done within medical training in general, and 2) what could be done within research opportunities provided to students during medical training.

Practical implications for medical training in general
Some practical implications derived from our research can be used and carried out regardless of whether hands-on research opportunities for students are implemented in medical training as well. Medical educators should:

- Connect research to practice – show students what research means for clinical practice and in particular patients. This helps to stimulate awareness and positive perceptions of the importance of research for clinical practice, which is associated with increasing intrinsic motivation for research as well. Furthermore, this also contributes to feelings of personal meaning regarding research;
- Expose students to inspiring scientific role models – reading of scientific articles could be included within different courses and students should also hear about research-related work from enthusiastic researchers. These enthusiastic researchers may serve as inspiring role models as well. Many medical educators also conduct research and thus have the ability to communicate their work in an enthusiastic manner during lectures or seminars;
- Spark students' curiosity – create a safe learning environment and stimulate students to ask questions. Furthermore, students should be actively involved in answering questions and finding answers to problems, thereby emphasizing the gaps in our current knowledge resulting in stimulating inquiry;
- Identify students with a need for extra challenge – students with a need for extra challenge could then be approached to explore if conducting research might be a way to fulfil their need for extra challenge;

- Expose students to research opportunities during early phases of medical training – By offering students research related courses adapted to their level early on in medical training, ambiguity and uncertainty surrounding conducting research decrease, which is important for increasing self-efficacy beliefs and motivation.[12]

Practical implications for exposing students to research opportunities

It is of crucial importance to expose students to research experiences. When it comes to connecting research to practice, the 12 tips as proposed in **chapter 12** could offer in-depth insights into how research initiatives in which students conducts research in early phases of medical training could be designed. An overview of the 12 tips is provided in box 2.

Box 2. Overview of the 12 tips as proposed in chapter 12

1. Provide an experiential opportunity by involving students in every stage of the scientific research process
2. Provide authentic research experiences with real patient data and opportunities to answer relevant clinical research questions
3. Distribute data collection over all students to make it feasible within a short course
4. Stimulate curiosity with relevant clinical examples
5. Give students autonomy in conducting their own research project
6. Provide research experiences to students in large as well as smaller group sessions
7. Use the smaller group sessions to scaffold the research processes
8. Use inspiring researchers as teachers of the small group sessions
9. Implement peer discussion within the course
10. Let students disseminate their work by writing a professional academic piece
11. Let students orally present or display their final work
12. Include different types of assessment and provide feedback on both the report and presentation

When integrating a course in which every student conducts research individually, it is important to acknowledge that not every student will pursue a research oriented career. However, in line with the third competency of the CanMEDS scholar role, the purpose of providing students with research experiences is not only to cultivate future physician-scientists, but to deliver graduates with an academic mindset as well. Key in connecting research to practice and exposing students to research experiences seems to be to start within early phases of medical training and to submerge students in every aspect of the research process. In this way, future educational purposes and the need to learn about and conduct research become more clear. Furthermore, it is noteworthy to mention that not in every medical school there is an opportunity to integrate a course within the core curriculum, however, most of the proposed tips might also be of value when designing an elective course.

Besides the practical implications as a result of our chapter intentionally connecting research to practice, practical implications regarding how students should be exposed to research can be derived from our other chapters as well:

- Offer students the chance to work on their research learning goals and mastery of research activities;
- Make extracurricular initiatives widely accessible for undergraduate students;
- Target unrealistic perceptions of research – for instance within our qualitative study, students tended to think that research is merely statistics. This unrealistic perception could be targeted and adjusted, while showing the importance of applying statistics for finding research results, the latter being very motivating for students;
- Let students apply statistics directly to authentic research questions – in this way, the relevance of statistics for creating results and finding answers to important questions is made apparent;
- Let students experience autonomy and the ability to work independently – students should feel ownership over their research, which could be accomplished by stimulating students to take a leading role in carrying out their research and providing students with multiple choices regarding, for instance, the topic of their research;
- Provide students with opportunities to learn from and rely on an experienced research mentor – while being leader of their own research project, a more experienced researcher should closely monitor their development and provide support when needed;

- Promote feelings of social connectedness – network and community building initiatives to socially connect both students with research mentors as well as students with near-peers conducting research should be implemented;
- Authentic assessment of students within research courses should be implemented – in particular presenting one's research with the opportunity for feedback dialogue seems of crucial importance. In line with that, students could also be stimulated to give presentations at a scientific conference or to publish their work in order to stimulate long-term research engagement.

These practical implications could not only contribute to students' success experiences in conducting research, but to achieve successful outcomes in general as well – for instance Kuh and O'Donnell identified setting appropriate performance expectations, offering students constructive feedback, and working towards a public demonstration of competence as elements of high impact practices to achieve successful outcomes for undergraduate students in higher education.[31]

A final word

After showing that an MD-PhD programme is a successful approach to train physician-scientists, Milewicz and her colleagues argued that initiatives to train physician-scientists may be extended to postgraduate training.[32] With this thesis, however, I hope we can rightfully suggest that these efforts could also be pointed at undergraduate medical students. Building on the work of others pioneering within the topic of cultivating future physician-scientists, this thesis contributed to scientific and practical understanding of how medical training could contribute to developing future physician-scientists and the impact of directing our efforts towards early phases of medical training in order to "catch them young".

References

1. Amgad M, Man Kin Tsui M, Liptrott SJ, Shash E. Medical Student Research: An Integrated Mixed-Methods Systematic Review and Meta-Analysis. *PloS one*. 2015;10(6):e0127470.
2. Chang YJ, Ramnanan CJ. A Review of Literature on Medical Students and Scholarly Research: Experiences, Attitudes, and Outcomes. *Academic Medicine*. 2015;90(8):1162-1173.
3. Waaijer CJF, Ommering BWC, van der Wurff LJ, van Leeuwen TN, Dekker FW, Education NSIGoS. Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. *Perspectives on Medical Education*. 2019;8(4):223-229.
4. Ten Cate TJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. *Medical Teacher*. 2011;33(12):961-973.
5. Rosenkranz SK, Wang S, Hu W. Motivating medical students to do research: a mixed methods study using Self-Determination Theory. *BMC Medical Education*. 2015;15(1):95.
6. Ten Cate O. Medical education in the Netherlands. *Med Teach*. 2007;29(8):752-757.
7. Wijnen-Meijer M, Burdick W, Alofs L, Burgers C, ten Cate O. Stages and transitions in medical education around the world: clarifying structures and terminology. *Medical Teacher*. 2013;35(4):301-307.
8. Imafuku R, Saiki T, Kawakami C, Suzuki Y. How do students' perceptions of research and approaches to learning change in undergraduate research? *International journal of medical education*. 2015;6:47-55.
9. Ryan RM, Deci EL. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 2000;55(1):68-78.
10. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications; 2017.
11. Ranieri V, Barratt H, Fulop N, Rees G. Factors that influence career progression among postdoctoral clinical academics: a scoping review of the literature. *BMJ open*. 2016;6(10):e013523.
12. Bandura A. *Self-Efficacy. The Exercise of Control*. New York: Freeman; 1997.
13. Merrill MD. First principles of instruction. *Educational Technology Research and Development*. 2002;50(3):43-59.
14. Carless D, Boud D. The development of student feedback literacy: enabling uptake of feedback. *Assessment & Evaluation in Higher Education*. 2018;43(8):1315-1325.
15. Bakken LL, Byars-Winston A, Wang MF. Viewing clinical research career development through the lens of social cognitive career theory. *Advances in Health Sciences Education: theory and practice*. 2006;11(1):91-110.
16. Wald N, Harland T. A framework for authenticity in designing a research-based curriculum. *Teaching in Higher Education*. 2017;22(7):751-765.
17. Ajzen I. The theory of planned behavior. *Organizational behavior and human decision processes*. 1991;50(2):179-211.
18. Vereijken MWC, van der Rijst RM, de Beaufort AJ, van Driel JH, Dekker FW. Fostering first-year student learning through research integration into teaching: Student perceptions, beliefs about the value of research and student achievement. *Innovations in Education and Teaching International*. 2016:1-8.
19. Litman JA. Interest and deprivation factors of epistemic curiosity. *Personality and Individual Differences*. 2008;44(7):1585-1595.

20. Berlyne DE. A theory of human curiosity. *British journal of psychology.* 1954;45(3):180-191.

21. Ommering BWC, Haramati A, de Jong PGM. Teaching to Develop Scientific Engagement in Medical Students. In: Huggett KN, Jeffries WB, eds. *An Introduction to Medical Teaching: The Foundations of Curriculum Design, Delivery, and Assessment. In press.*

22. Shanahan JO, Ackley-Holbrook E, Hall E, Stewart K, Walkington H. Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature. *Mentor Tutor.* 2015;23(5):359-376.

23. Havnaer AG, Chen AJ, Greenberg PB. Scholarly concentration programs and medical student research productivity: a systematic review. *Perspectives on Medical Education.* 2017;6(4):216-226.

24. Radville L, Aldous A, Arnold J, Hall AK. Outcomes from an elective medical student Research Scholarly Concentration program. *Journal of investigative medicine.* 2019;67(6):1018-1023.

25. Wolfson RK, Alberson K, McGinty M, Schwanz K, Dickins K, Arora VM. The Impact of a Scholarly Concentration Program on Student Interest in Career-Long Research: A Longitudinal Study. *Academic Medicine.* 2017;92(8):1196-1203.

26. Weaver AN, McCaw TR, Fifolt M, Hites L, Lorenz RG. Impact of elective versus required medical school research experiences on career outcomes. *Journal of investigative medicine.* 2017;65(5):942-948.

27. Steenman SC, Bakker WE, van Tartwijk JWF. Predicting different grades in different ways for selective admission: disentangling the first-year grade point average. *Studies in Higher Education.* 2016;41(8):1408-1423.

28. Richardson D, Oswald A, Lang E, Harvey B, Chan M-K. *The CanMEDS 2015 Scholar Expert Working Group Report.* Ottawa: The Royal College of Physicians and Surgeons of Canada;2014.

29. Kool A, Mainhard T, Jaarsma D, van Beukelen P, Brekelmans M. Effects of honours programme participation in higher education: a propensity score matching approach. *Higher Education Research & Development.* 2017;36(6):1222-1236.

30. Herwaarden CLA, Laan RFJM, Leunissen R. *Raamplan artsopleiding 2009.* Nederlandse Federatie van Universitair Medische Centra (NFU); 2009.

31. Kuh GD, O'Donnell K. *Ensuring Quality & Taking High-impact Practices to Scale.* Washington D.C.: AAC&U, Association of American Colleges and Universities; 2013.

32. Milewicz DM, Lorenz RG, Dermody TS, Brass LF, National Association of MDPPEC. Rescuing the physician-scientist workforce: the time for action is now. *The Journal of clinical investigation.* 2015;125(10):3742-3747.

Summary

Nederlandse samenvatting

Supplements

List of scientific contributions

Dankwoord

Curriculum Vitae

Summary

In *chapter 1*, we set the stage for the research conducted within this thesis. Medical education should contribute to delivering future physicians that are able to use research in order to practice evidence-informed decision making. However, physicians conducting research are needed as well. These physician-scientists are in the unique position to connect practice and research, and are thereby important to make advancements within the medical field. Currently, the medical field is facing a physician-scientist shortage and the need to identify how medical training could contribute to cultivating future physician-scientists inspired the main focus of this thesis: provide insights into the role early phases of medical education could play in developing future physician-scientists, by unravelling the role of motivation for research and extracurricular research programmes. These insights could help to shed light on practical implications and determine possibilities for interventions to enhance motivation for as well as involvement in research, both intra- and extracurricular. As previous research showed that involvement in research during medical training is related to further research involvement during professional practice, first steps to foster the future physician-scientist workforce could well be made early on in medical education.

In *chapter 2* we identified levels of intrinsic and extrinsic motivation for research among first-year medical students. Furthermore, we examined factors influencing their levels of research motivation at the start of medical training. We administered a questionnaire within the first three months of the medical bachelor programme. Students reported their intrinsic motivation for research, extrinsic motivation for research, self-efficacy beliefs, perceptions of research, curiosity, and need for challenge on a 7-point Likert scale. Out of the 316 approached students, 315 participated in this study (99.7%). On average, students scored 5.49 on intrinsic, and 5.66 on extrinsic motivation for research. Self-efficacy beliefs, perceptions of research, curiosity, and need for challenge were all positively associated with intrinsic and extrinsic motivation for research, also after adjusting for gender and age. These constructs together explained 40% of the variance in intrinsic motivation for research, while only explaining 14% of the variance in extrinsic motivation for research. The findings from this study imply that first-year medical students enter medical training motivated for research. Furthermore, motivation for research could be enhanced by stimulating positive self-efficacy beliefs, positive perceptions of research, and curiosity. In addition, it is important to identify

students with a need for extra challenge, as they could be stimulated to fulfil this need by conducting research.

In *chapter 3* we identified conditions under which students develop positive perceptions of and motivation for research, by using a grounded theory approach to elucidate how first-year medical students perceive research and which factors contribute to motivation or demotivation to conduct research. We conducted individual interviews with 13 purposively sampled first-year medical students. This study revealed that first-year medical students differed greatly in their perceptions of and motivation for research. However, they were able to identify many aspects of research, thereby showing a broad perspective of what conducting research entails. Among other things, students mentioned acknowledgment, autonomy, and inspiring role models as motivating factors. Lack of autonomy, lack of relevance, and inadequate collaboration, on the other hand, were labelled as demotivating. Our findings were partly in line with some major motivational theories, like the Self-Determination Theory (SDT). In line with the SDT, our findings implied that autonomy, relatedness, and competence are important in influencing motivation for research. Additionally, relevance, need for challenge, curiosity, and inspiring role models were identified as positively influencing motivation for research. In order to motivate students for research, it therefore seems important to create research environments in which these motivating factors are stimulated, for instance by providing students with choices within their research. In addition, our results suggested a relationship between perceptions of and motivation for research, as some perceptions were identical to motivating or demotivating factors to conduct research, like the relevance of research for practice and performing statistics respectively. As our results suggested that perceptions of research are related to motivation for research, this offers possibilities for interventions to promote motivation for research through students' perceptions of research.

In *chapter 4* we had the aim to examine if medical students' motivation for research is related to actual research involvement. In addition, we distinguished intrinsic and extrinsic motivation for research to investigate if type of motivation mattered in the relation between research motivation and research involvement. We conducted a prospective cohort study in which students filled in a questionnaire at the start of medical training, reporting on intrinsic motivation for research, extrinsic motivation for research, self-efficacy beliefs, perceptions of research, and curiosity on a

7-point Likert scale. One year later, students involved in research were identified. Research involvement was operationalised as 1) participating within the research-based Honours programme of Leiden University Medical Center, or 2) conducting extracurricular research outside of the Honours programme. A total of 315 out of 316 approached students participated (99.7%), of whom 55 were identified as involved in research (17.5%). Our results suggested that students with higher levels of intrinsic motivation for research were more often involved in research, also after adjusting for gender, age, extracurricular high-school activities, self-efficacy beliefs, perceptions of research, and curiosity. Higher levels of extrinsic motivation increased the odds of research involvement, however after adjusting for the above mentioned factors the effect of extrinsic motivation for research on research involvement disappeared. In addition, the effect of intrinsic motivation for research remained after adjusting for extrinsic motivation for research, whereas the effect of extrinsic motivation disappeared after adjusting for intrinsic motivation for research. Thus, our findings showed that extrinsic motivation for research did not contribute on top of intrinsic motivation for research. Our findings suggest that type of motivation matters and particularly intrinsic research motivation influences research involvement. This is in line with the SDT, stating that intrinsic motivation is of better quality. Therefore, intrinsic research motivation could be targeted to stimulate research involvement and could be seen as a first step towards success in fostering the physician-scientist workforce. Subsequently, within our following studies we shifted towards investigating how in particular intrinsic motivation for research could be enhanced during early phases of medical education.

In *chapter 5* we examined if success experiences within an undergraduate course in academic and scientific skills increased intrinsic motivation for research and research self-efficacy beliefs among medical students. Furthermore, we elaborated on type of success experience as we studied the effects of academic success experiences within standard (i.e. written exam) and authentic (i.e. written research report and oral presentation) assessments. Regarding this secondary aim, we hypothesized that authentic assessments influence intrinsic motivation for research and self-efficacy beliefs to a larger degree than standard assessments, as the authentic assessments mirror real-world practices of researchers. To answer our research questions, students following an obligatory course in academic and scientific skills, in which they conducted research individually, were included in this study. Their academic success experiences were operationalised as their grades on two authentic research assessments (written report and oral presentation) and one less authentic assessment (written exam). We surveyed students before the course when entering medical school (i.e. baseline measure) and one year after the course in their second year (i.e. post-measure). Both at the baseline and post-measure surveys, we measured intrinsic motivation for research, extrinsic motivation for research, and research self-efficacy beliefs. In total, 243 out of 275 students participated within this study (88.4%). Our findings suggested that, after adjusting for motivational baseline scores, age, gender, and GPA of the first four months prior to the obligatory research course, only an academic success experience in orally presenting one's research is related to an increase in both intrinsic motivation for research and research self-efficacy beliefs. Higher grades on the exam did not affect intrinsic motivation for research or research self-efficacy significantly. Thus, our findings imply that an academic success experience within a research course could be related to enhancing intrinsic motivation for research and self-efficacy beliefs, however, authentic assessment is important. In particular presenting your own research seems to be a good way to enhance intrinsic motivation for research and research self-efficacy beliefs, which in turn promotes research involvement. Furthermore, this study established the applicability of the Social Cognitive Theory in a research context within the medical domain.

In *chapter 6* we expanded the success experience perspective by perceiving publishing research as a form of experiencing research success. The aim of this study was to examine the relationship between academic publishing during medical education and post-graduation publication careers. In total, 4145 graduates receiving their degree between 2005 and 2008 from all eight Dutch university medical centres were included in the current study. These students were matched to their publications indexed in the Web of Science, published between 6 years before and 6 years after graduation. For sensitivity analysis both automatic assignment on the whole group and manual assignment on a 10% random sample was performed. Our findings showed that students who had published before graduation were almost two times as likely to publish after graduation, published more papers, and had a slightly higher citation impact after graduation. These results cautiously suggest that successful early involvement in research could influence long-term research involvement among medical graduates.

Chapter 7 is a commentary, in which we elaborate on motivation for research among medical students as preparation for their residency. Our key message within this commentary is the importance of acknowledging the dynamic character of motivation for research. From our studies, it seems that mainly intrinsic motivation for research should be targeted. However, we do think it is important to acknowledge the possibility that extrinsically motivated students can become intrinsically motivated for research along the way. Intrinsic motivation for research is, according to our studies and the SDT, related to better outcomes. Nonetheless, according to SDT, one can shift on the motivation continuum and a process of internalization could take place. This corroborates the idea that extrinsic motivation could indeed turn into intrinsic motivation. Within this chapter we discussed that students might start participating in research because of extrinsic motivators, like for instance conducting research to secure a competitive residency spot, but that these same students could become intrinsically motivated while becoming more and more familiar with research. Through research involvement, students for instance might as well discover their own talents and research competencies, which could then contribute to enhancing intrinsic motivation for research.

In *chapter 8* we described the research-based Honours programme of Leiden University Medical Center, an initiative to engage future physicians into scientific research in early stages of medical training. Our programme starts in the second year of medical training and is comprised of four different tracks (i.e. MD/PhD track, Journey into Biomedical Sciences track, Clinical Research/Epidemiology track, and Free Research track), sharing the common goal to involve students in research. As a result of the unique multiple-track model, attracting diverse students with varying interests, the programme accommodates about 50-70 students (25% of the entire cohort) each year. The programme has a duration of two years, and is mainly based on self-selection without very strict institutional criteria. To get a certificate for this programme, students need to obtain 30 extra credits (ECTS, i.e. European Credit Transfer and Accumulation System, which means that students have to invest 30 x 28 hours of active study). At the same time, they have to obtain 180 regular ECTS for their three-year Bachelor programme with a grade point average (GPA) of at least 7 on a 10-point grading scale. Internationally, this programme could be seen as an extracurricular research programme, which are believed to play a possible important role in cultivating future physician-scientists.

In *chapter 9* we reported on the role of grades in selecting students for an extracurricular research programme, by comparing students with lower and higher previous academic performance on subsequent academic performance, extracurricular research programme performance, and motivational factors (i.e. intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity). Within a prospective cohort study, students filled in a yearly questionnaire on the motivational factors. Two groups participating in an extracurricular research programme were compared: students with first-year GPA ≥7 versus <7. Students in the <7 group had a significantly lower third-year GPA and significantly higher odds for drop-out from the extracurricular research programme. Students in the <7 group did, however, obtain their bachelor degree in the same amount of time and were not inferior to the ≥7 group in terms of intrinsic motivation for research, perceptions of research, and curiosity. Intrinsic motivation for research, perceptions of research, and curiosity are all factors underlying research involvement in future professional practice. Therefore, if the pre-eminent goal of extracurricular research programmes is to develop physician-scientists, our findings imply that it seems beneficial to shift from an emphasis on selecting solely based on grades towards selection based on a combination of grades and non-cognitive criteria, such as motivation.

In *chapter 10* we aimed to identify effects of an extracurricular research programme. Previous studies into the effects of extracurricular research programmes are mainly retrospective, lacking baseline measurements and control groups. Therefore, we conducted a prospective study with a longitudinal design, sound baseline measurements, and a comparable control group to investigate the effects of our extracurricular research programme. Ideally, one would aspire a randomized controlled trial (RCT) in order to examine the effects of the extracurricular research programme, dividing students who expressed interest in the programme in a participating and a non-participating group at random. However, as randomization is not possible here, we tried to mimic an RCT by comparing students starting the extracurricular research programme to students that have showed interest in the extracurricular research programme, but eventually decided not to participate, on academic achievement (i.e. in-time bachelor completion, bachelor GPA) after two years and motivational factors (i.e. intrinsic motivation for research, research self-efficacy beliefs, perceptions of research, and curiosity) after 18 months. Furthermore, we adjusted for potentially relevant baseline differences to make the groups as comparable as possible. Our findings suggested that starting in the extracurricular research programme is positively related to in-time bachelor completion. Furthermore, starting the extracurricular research programme was related to higher levels of intrinsic motivation for research, also after adjusting for gender, age, first-year GPA, and motivational baseline scores. No effect was found on research self-efficacy beliefs, perceptions of research, and curiosity. As previous research suggested that intrinsic motivation is related to short- and long-term research engagement, the extracurricular research programme may be seen as an important first step into the physician-scientist pipeline.

Chapter 11 is a theoretical essay in which we tried to connect our research to theory and expand our theoretical view on the SDT by including an authenticity framework to shape undergraduate research experiences and promote student wellbeing. We elaborated on the importance of authentic undergraduate research experiences, while using Wald and Harland's three definitions of authenticity: 1) authenticity as relating to the real word (e.g. learning mirroring the real world), 2) the existential authentic self (e.g. developing self-identity and feelings of ownership to become an independent learner), and 3) a degree of personal meaning (depending on wat students deem important on a personal level). Based on these definitions and the proposed authenticity framework, we discussed ways to design higher education curricula in such ways that learning spaces are inclusive and foster wellbeing. This could be achieved through promoting autonomy, competence, and relatedness as proposed by SDT and by stimulating social connectedness between students and mentors as well as students and peers.

In *chapter 12* we tried to connect our research to practice by proposing twelve tips to offer students the experience to conduct research individually as part of the core curriculum. Most medical schools educate large numbers of students at the same time, especially in early phases of medical training. Large scale education on the one hand and individually providing students with authentic experiences on the other hand is considered not that easy to achieve. Therefore, building on our own experiences, existing literature, and theories we proposed the following twelve tips to design and implement a course in which authentic individual research experiences can be provided to a large group of undergraduate students: 1) provide an experiential opportunity by involving students in every stage of the scientific research process, 2) provide authentic research experiences with real patient data and opportunities to answer relevant clinical research questions, 3) distribute data collection over all students to make it feasible within a short course, 4) stimulate curiosity with relevant clinical examples, 5) give students autonomy in conducting their own research project, 6) provide research experiences to students in large as well as smaller group sessions, 7) use the smaller group sessions to scaffold the research processes, 8) use inspiring researchers as teachers of the small group sessions, 9) implement peer discussion within the course, 10) let students disseminate their work by writing a professional academic piece, 11) let students orally present or display their final work, and 12) include different types of assessment and provide feedback on both the report and presentation.

In *chapter 13* we discussed our reflections on the findings from the studies described in the previous chapters, in order to provide insights into the impact early phases of medical training may have on cultivating future physician-scientists. We elaborated on the role of awareness and intrinsic motivation for research, discussing that in order to stimulate young medical students to acknowledge the possibility for a physician-scientist career and subsequently pursue this career path, our studies altogether suggest that three overarching topics play an important role: awareness, motivation, and opportunity. As our results showed that even the first-year students are already aware of the importance of research for clinical practice and that they enter medical education motivated for research, in line with the title of this thesis we believe that we could indeed 'catch students young'. Furthermore, we elaborate on ways to stimulate intrinsic motivation for research according to existing theoretical perspectives and our research findings, the role of extracurricular research programmes within medical training (i.e. the 'opportunity'), and the dynamic character of motivation for research, resulting in practical implications for medical training in general and practical implications for exposing students to research opportunities. Practical implications for medical training in general are: 1) connect research to practice, 2) expose students to inspiring scientific role models, 3) spark students' curiosity, 4) identify students with a need for extra challenge, and 5) expose students to research opportunities during early phases of medical training. In addition to the twelve tips as proposed in chapter 12, practical implications for exposing students to research opportunities are: 1) offer students the chance to work on their research learning goals and mastery of research activities, 2) make extracurricular initiatives widely accessible for medical students in early phases of medical education, 3) target unrealistic perceptions of research, 4) let students apply statistics to authentic research questions, 5) let students experience autonomy and the ability to work independently, 6) provide students with opportunities to learn from and rely on an experienced research mentor, 7) promote feelings of social connectedness, and 8) implement authentic assessment of students within research courses.

Nederlandse samenvatting

In *hoofdstuk 1* beschrijven we de grotere context en setting waarin het onderzoek uit dit proefschrift is uitgevoerd. Medisch onderwijs zou bij moeten dragen aan het afleveren van toekomstige artsen die in staat zijn onderzoek te gebruiken, om op die manier op basis van beschikbaar bewijs ('evidence-informed') te handelen in de praktijk. Daarnaast heeft het medische veld echter ook artsen nodig die onderzoek doen. Deze arts-onderzoekers bevinden zich in de unieke positie om praktijk en onderzoek te verbinden, en daarmee zijn ze belangrijk om vooruitgang te boeken binnen het medische domein. Momenteel is er in het medische veld sprake van een tekort aan arts-onderzoekers. De behoefte om te identificeren hoe medisch onderwijs bij kan dragen aan het kweken van toekomstige arts-onderzoekers heeft het hoofdthema binnen dit proefschrift geïnspireerd: het bieden van inzicht in de rol van vroege fases in de medische opleiding om toekomstige arts-onderzoekers te ontwikkelen, door de rol van motivatie voor onderzoek en extracurriculaire onderzoekprogramma's te ontrafelen. Deze inzichten kunnen helpen om praktische implicaties te identificeren en mogelijkheden voor interventies te bepalen, zowel intra- als extracurriculair, met het doel om motivatie voor onderzoek en betrokkenheid bij onderzoek onder studenten te vergroten. Aangezien eerder onderzoek heeft aangetoond dat betrokkenheid bij onderzoek tijdens de medische opleiding gerelateerd is aan betrokkenheid bij onderzoek als medisch professional, kunnen eerste stappen om het aantal toekomstige arts-onderzoekers te waarborgen wellicht al vroeg binnen het medisch onderwijs gezet worden.

In *hoofdstuk 2* hebben we de mate van intrinsieke en extrinsieke motivatie voor onderzoek onder eerstejaars medische studenten geïdentificeerd. Daarnaast hebben we factoren onderzocht die deze mate van motivatie voor onderzoek aan het begin van de opleiding beïnvloeden. We hebben een vragenlijst uitgezet in de eerste drie maanden van het medische Bachelor programma. Studenten hebben de mate van intrinsieke motivatie voor onderzoek, extrinsieke motivatie voor onderzoek, self-efficacy gevoelens, percepties van onderzoek, nieuwsgierigheid en behoefte aan uitdaging gerapporteerd op een 7-punt Likert schaal. Van de 316 benaderde studenten, hebben 315 studenten geparticipeerd in deze studie (99.7%). Studenten scoorden gemiddeld 5.49 op intrinsieke en 5.66 op extrinsieke motivatie voor onderzoek. Self-efficacy gevoelens, percepties van onderzoek, nieuwsgierigheid en behoefte aan uitdaging waren positief geassocieerd met zowel intrinsieke als extrinsieke motivatie voor onderzoek, ook na gecorrigeerd te hebben voor leeftijd en geslacht. Tezamen verklaarden deze constructen 40% van de variantie in intrinsieke motivatie voor onderzoek en slechts 14% van de variantie in extrinsieke motivatie voor onderzoek. De bevindingen uit deze studie impliceren dat eerstejaars medische studenten gemotiveerd voor onderzoek aan de medische opleiding beginnen. Bovendien kan motivatie voor onderzoek vergroot worden door positieve self-efficacy gevoelens, positieve percepties van onderzoek en nieuwsgierigheid te stimuleren. Daarnaast is het belangrijk om studenten met behoefte aan extra uitdaging te identificeren, aangezien zij gestimuleerd zouden kunnen worden om tegemoet te komen aan deze behoefte door het doen van onderzoek.

In *hoofdstuk 3* hebben we condities geïdentificeerd waaronder studenten positieve percepties van en motivatie voor onderzoek ontwikkelen, gebruikmakend van een grounded theory benadering om te verduidelijken hoe eerstejaars medische studenten onderzoek percipiëren en welke factoren bijdragen aan motivatie of demotivatie voor het doen van onderzoek. We hebben individuele interviews uitgevoerd met 13 doelgericht benaderde eerstejaars medische studenten. Deze studie heeft aangetoond dat eerstejaars medische studenten enorm varieerden in percepties van en motivatie voor onderzoek. Echter, ze waren wel al in staat om veel aspecten van onderzoek te identificeren en toonden op die manier een breed perspectief over het doen van onderzoek. Onder andere erkenning, autonomie en inspirerende rolmodellen werden genoemd als motiverende factoren. Een gebrek aan autonomie, gebrek aan relevantie en inadequate samenwerking werden bestempeld als demotiverend. Onze bevindingen waren gedeeltelijk in lijn met grote motivatietheorieën, zoals bijvoorbeeld de Self-Determination Theory (SDT). In lijn met de SDT impliceerden onze bevindingen dat autonomie, verbondenheid en competentie belangrijk zijn in het beïnvloeden van motivatie voor onderzoek. Daarnaast werden relevantie, behoefte aan uitdaging, nieuwsgierigheid en inspirerende rolmodellen geïdentificeerd als aspecten die motivatie voor onderzoek positief beïnvloeden. Om studenten te motiveren voor onderzoek lijkt het daarom dus belangrijk om onderzoekomgevingen te creëren waarin deze motiverende factoren gestimuleerd worden, bijvoorbeeld door studenten keuzes te bieden binnen het uitvoeren van het eigen onderzoek. Bovendien suggereerden onze resultaten een relatie tussen percepties van en motivatie voor onderzoek, aangezien sommige percepties identiek waren aan genoemde motiverende of demotiverende factoren om onderzoek te doen, zoals respectievelijk de relevantie van onderzoek voor de praktijk en statistiek. Daar onze resultaten suggereren dat percepties van onderzoek gerelateerd zijn aan motivatie voor onderzoek, biedt dit mogelijkheden voor interventies ingezet op het stimuleren van motivatie voor onderzoek via de percepties die studenten bij onderzoek hebben.

In *hoofdstuk 4* hadden we het doel om te bekijken of motivatie voor onderzoek onder medische studenten gerelateerd is aan daadwerkelijke betrokkenheid bij onderzoek. We hebben daarbij onderscheid gemaakt in intrinsieke en extrinsieke motivatie voor onderzoek om in kaart te brengen of type motivatie van belang is in de relatie tussen motivatie voor onderzoek en betrokkenheid bij onderzoek. We hebben een prospectieve cohort studie uitgevoerd waarbij studenten een vragenlijst hebben ingevuld aan het begin van de medische opleiding, waarbij ze intrinsieke motivatie voor onderzoek, extrinsieke motivatie voor onderzoek, self-efficacy gevoelens, percepties van onderzoek en nieuwsgierigheid rapporteerden op een 7-punt Likert schaal. Een jaar later hebben we geïdentificeerd welke studenten betrokken zijn bij het doen van onderzoek. Betrokkenheid bij onderzoek werd geoperationaliseerd als 1) participeren in het sterk onderzoek georiënteerde Honours programma van het Leids Universitair Medisch Centrum of 2) het doen van extracurriculair onderzoek buiten het Honours programma. In totaal hebben 315 van de 316 benaderde studenten meegedaan (99.7%), waarvan er 55 betrokken waren bij onderzoek (17.5%). Onze resultaten suggereerden dat studenten met een hogere mate van intrinsieke motivatie voor onderzoek vaker ook daadwerkelijk betrokken raken bij onderzoek, ook na gecorrigeerd te hebben voor geslacht, leeftijd, extracurriculaire activiteiten op de middelbare school, self-efficacy gevoelens, percepties van onderzoek en nieuwsgierigheid. Een hogere mate van extrinsieke motivatie vergrootte de kans op betrokkenheid bij onderzoek, maar na gecorrigeerd te hebben voor de bovengenoemde factoren verdween het effect van extrinsieke motivatie voor onderzoek op betrokkenheid bij onderzoek. Tevens bleek dat het effect van intrinsieke motivatie voor onderzoek overeind bleef na gecorrigeerd te hebben voor extrinsieke motivatie voor onderzoek, terwijl het effect van extrinsieke motivatie voor onderzoek verdween na gecorrigeerd te hebben voor intrinsieke motivatie voor onderzoek. Onze bevindingen laten daarmee zien dat extrinsieke motivatie voor onderzoek niets bijdraagt bovenop intrinsieke motivatie voor onderzoek in de relatie met daadwerkelijke betrokkenheid bij onderzoek. Onze bevindingen laten zien dat type motivatie er toe doet en dat met name intrinsieke motivatie voor onderzoek betrokkenheid bij onderzoek beïnvloed. Dit is in lijn met de SDT, beargumenterend dat intrinsieke motivatie van betere kwaliteit is. Daarom zouden we ons moeten richten op intrinsieke motivatie voor onderzoek om betrokkenheid bij onderzoek te stimuleren en kan dit gezien worden als een eerste stap richting succes om het aantal toekomstige arts-onderzoekers te waarborgen. Als gevolg van deze studie hebben we in de volgende studies de focus verlegd naar het bestuderen van hoe met name intrinsieke motivatie voor onderzoek vergroot kan worden tijdens vroege fases van de medische opleiding.

In *hoofdstuk 5* onderzochten we of een succeservaring binnen het vak academische en wetenschappelijke vorming in het eerste jaar de intrinsieke motivatie voor en self-efficacy gevoelens over onderzoek onder medische studenten verhoogde. Daarnaast hebben we gekeken of type succeservaring een rol speelde, aangezien we het effect van een academische succeservaring binnen standaard (schriftelijk examen) en authentieke (schriftelijk verslag en mondelinge presentatie) toetsvormen hebben bestudeerd. Wat betreft dit tweede doel hadden we de hypothese dat het effect op het vergroten van intrinsieke motivatie voor en self-efficacy gevoelens over onderzoek groter zou zijn bij de authentieke toetsvormen. Om onze onderzoeksvraag te beantwoorden werden studenten die een verplicht vak in academische en wetenschappelijke vorming volgden, een vak waarin zij individueel onderzoek uitvoerden, geïncludeerd in deze studie. De academische succeservaring werd geoperationaliseerd als de cijfers van studenten op de twee authentieke opdrachten (schriftelijk verslag en mondelinge presentatie) en de minder authentieke toets (schriftelijk examen). We hebben studenten gevraagd een vragenlijst in te vullen vóór het vak (aan het begin van de medische opleiding; baseline meting) en een jaar na het vak (tweede jaar van de medische opleiding; nameting). Zowel bij de baseline meting als de nameting werd er gevraagd naar intrinsieke motivatie voor onderzoek, extrinsieke motivatie voor onderzoek en self-efficacy gevoelens over onderzoek. In totaal hebben 243 van de 275 studenten geparticipeerd in deze studie (88.4%). Onze bevindingen suggereerden dat, na gecorrigeerd te hebben voor de motivatiescores op baseline, leeftijd, geslacht en GPA van de eerste vier maanden voorafgaand aan het verplichte vak, alleen een academische succeservaring in het mondelinge presenteren van het eigen onderzoek gerelateerd is aan een toename in zowel intrinsieke motivatie voor onderzoek als self-efficacy gevoelens over onderzoek. Hogere cijfers op het examen hadden geen effect op intrinsieke motivatie voor of self-efficacy gevoelens over onderzoek. Onze bevindingen impliceren dus dat een academische succeservaring binnen een onderzoeksvak gerelateerd kan zijn aan het vergroten van intrinsieke motivatie voor en self-efficacy gevoelens over onderzoek, maar dat authentieke toetsing hierbij wel van belang is. Met name het presenteren van eigen onderzoek lijkt een goede manier te zijn om intrinsieke motivatie voor en self-efficacy gevoelens over onderzoek te vergroten, wat op hun beurt weer gerelateerd is aan het stimuleren van betrokkenheid bij onderzoek. Daarnaast heeft deze studie ook de toepasbaarheid van de Social Cognitive Theory aangetoond binnen een onderzoek context in het medische domein.

In *hoofdstuk 6* hebben we het succeservaring perspectief verder uitgebreid door publiceren van onderzoek te zien als een vorm van het ervaren van succes in onderzoek. Het doel van deze studie was om de relatie tussen academisch publiceren tijdens de medische opleiding en publicatie carrières na de opleiding te bekijken. In totaal werden 4145 afgestudeerden van alle acht Nederlandse medische faculteiten die hun diploma behaalden tussen 2005 en 2008 geïncludeerd in de huidige studie. Deze studenten werden gelinkt aan hun publicaties in Web of Science, welke gepubliceerd waren tussen 6 jaar voor en 6 jaar na afstudeerdatum. In het kader van een sensitiviteitsanalyse werd er zowel een automatisch toewijzing van publicaties over de hele groep gedaan, maar werd er ook een handmatige toewijzing gedaan op een random steekproef ter grootte van 10%. Onze resultaten laten zien dat studenten die publiceren voor afstuderen bijna twee keer zo vaak publiceren na afstuderen, dat ze meer papers publiceren en met een net wat grotere citatie impact. Met enige voorzichtigheid suggereren deze resultaten dat succesvolle vroege betrokkenheid in onderzoek invloed heeft op betrokkenheid bij onderzoek op de langere termijn.

Hoofdstuk 7 is een betoog, waarin we dieper ingaan op motivatie voor onderzoek onder medische studenten ter voorbereiding op de vervolgopleiding. Onze sleutelboodschap binnen dit betoog is het belang om het dynamische karakter van motivatie voor onderzoek te erkennen. Uit onze studies lijkt het zo te zijn dat er met name ingezet zou moeten worden op intrinsieke motivatie voor onderzoek. We denken echter wel dat het belangrijk is om te erkennen dat de mogelijkheid bestaat dat extrinsiek gemotiveerde studenten gaandeweg uiteindelijk intrinsiek gemotiveerd voor onderzoek raken. Intrinsieke motivatie voor onderzoek is volgens onze studies en de SDT gerelateerd aan betere uitkomsten. Desondanks stelt de SDT ook dat iemand kan verplaatsen op het motivatie continuüm en dat er een proces van internalisering plaats kan vinden. Dit ondersteunt het idee dat extrinsieke motivatie inderdaad kan veranderen in intrinsieke motivatie. In dit hoofdstuk bediscussieerden we dat studenten wellicht beginnen met het doen van onderzoek als een resultaat van extrinsieke motivatoren, zoals bijvoorbeeld het doen van onderzoek om een competitieve opleidingsplaats te bemachtigen, maar dat deze zelfde studenten ook intrinsiek gemotiveerd kunnen raken terwijl ze meer bekend raken met onderzoek. Door betrokkenheid bij onderzoek kunnen studenten bijvoorbeeld eigen talent en onderzoek competenties ontdekken, wat dan weer kan bijdragen aan het vergroten van de intrinsieke motivatie voor onderzoek.

In *hoofdstuk 8* beschrijven we het sterk op onderzoek georiënteerde Honours programma van het Leids Universitair Medisch Centrum, een initiatief om toekomstige artsen al in vroege fases van de medische opleiding te betrekken bij wetenschappelijk onderzoek. Ons programma start in het tweede jaar van de medische opleiding en bestaat uit vier verschillende mogelijk te volgen tracks (MD/PhD track, Journey into Biomedical Sciences track, klinisch onderzoek/epidemiologie track en de vrije onderzoek track), met het gedeelde doel om studenten te betrekken in onderzoek. Als een resultaat van dit unieke model met meerdere tracks, waarbij studenten worden aangetrokken met variërende interesses, accommodeert het programma jaarlijks ongeveer 50-70 studenten (25% van het gehele cohort). Het programma heeft een duur van twee jaar en is voornamelijk gebaseerd op zelfselectie zonder erg strikte criteria vanuit het instituut. Om een certificaat van dit programma te ontvangen, moeten studenten 30 extra credits (ECTS – ‘European Credit Transfer and Accumulation System’, wat betekent dat studenten 30 x 28 uren van actieve studie moeten investeren) verkrijgen. Tegelijkertijd moeten ze 180 reguliere ECTS verkrijgen voor het driejarige Bachelor programma met een gemiddeld eindcijfer van minimaal 7 (uit 10). Dit programma kan gezien worden als wat internationaal een extracurriculair onderzoeksprogramma wordt genoemd om toekomstige arts-onderzoekers te kweken.

In *hoofdstuk 9* rapporteren we over de rol van cijfers in het selecteren van studenten voor een extracurriculair onderzoeksprogramma, door studenten met lagere en hogere voorgaande academische prestaties te vergelijk op daaropvolgende academische prestaties, prestaties binnen het extracurriculaire onderzoeksprogramma en motivatie factoren (namelijk intrinsieke motivatie voor onderzoek, self-efficacy gevoelens over onderzoek, percepties van onderzoek en nieuwsgierigheid). Binnen een prospectieve cohort studie hebben studenten jaarlijks een vragenlijst ingevuld betreffende de motivatie factoren. Twee groepen die participeerden binnen het extracurriculaire onderzoeksprogramma zijn vergeleken: studenten met een gemiddeld eerstejaarscijfer ≥7 versus <7. Studenten in de <7 groep hadden een lager gemiddelde cijfer in het derde jaar en een grotere kans om uit te vallen uit het extracurriculaire onderzoeksprogramma. Studenten in de <7 groep behaalden echter wel het bachelor diploma in een vergelijkbare tijd en waren niet inferieur aan de ≥7 groep wat betreft intrinsieke motivatie voor onderzoek, percepties van onderzoek en nieuwsgierigheid. Intrinsieke motivatie voor onderzoek, percepties van onderzoek en nieuwsgierigheid zijn allen factoren onderliggend aan betrokkenheid bij onderzoek als toekomstig professional. Als bij uitstek het doel van een extracurriculair onderzoeksprogramma is om arts-onderzoekers te ontwikkelen, impliceren onze resultaten dat het waardevol is om de nadruk van selecteren puur op basis van cijfers te verschuiven naar selecteren op basis van een combinatie van cijfers en niet-cognitieve criteria, zoals motivatie.

In *hoofdstuk 10* wilden we effecten van een extracurriculair onderzoeksprogramma identificeren. Eerdere onderzoeken naar de effecten van extracurriculaire onderzoeksprogramma's zijn met name retrospectief en hebben geen baseline meting of controlegroep. Daarom hebben we in deze studie een longitudinaal design gecombineerd met een baseline meting en een vergelijkbare controlegroep om de effecten van ons extracurriculaire onderzoeksprogramma in kaart te brengen. Idealiter zou een 'randomized controlled trial' (RCT) geaspireerd worden om de effecten van het extracurriculaire onderzoeksprogramma in kaart te brengen door studenten die interesse hebben getoond in het programma random te verdelen in een participerende en niet-participerende groep. Echter, aangezien randomiseren in deze context niet mogelijk is, hebben we geprobeerd een RCT na te bootsen door studenten die het extracurriculaire onderzoeksprogramma starten te vergelijken met studenten die interesse hebben getoond in het extracurriculaire onderzoeksprogramma, maar uiteindelijk hebben besloten niet te participeren. We vergelijken de twee groepen studenten op academische prestaties (het nominaal lopen in de bachelor en het gemiddeld eindcijfer van de bachelor) na twee jaar en motivatie factoren (intrinsieke motivatie voor onderzoek, self-efficacy gevoelens over onderzoek, percepties van onderzoek en nieuwsgierigheid) na 18 maanden. Bovendien hebben we gecorrigeerd voor mogelijk relevante baseline verschillen om de groepen zo vergelijkbaar mogelijk te maken. Onze bevindingen suggereren dat starten in het extracurriculaire onderzoeksprogramma positief gerelateerd is aan het nominaal lopen in de bachelor. Daarnaast is starten in het extracurriculaire onderzoeksprogramma gerelateerd aan hogere niveaus van intrinsieke motivatie voor onderzoek, ook na gecorrigeerd te hebben voor geslacht, leeftijd, gemiddeld cijfer van het eerste jaar en motivatiefactoren op de baseline. Er werd geen effect gevonden op self-efficacy gevoelens over onderzoek, percepties van onderzoek en nieuwsgierigheid. Aangezien eerder onderzoek heeft aangetoond dat intrinsieke motivatie is gerelateerd aan korte- en lange termijn betrokkenheid bij onderzoek, kan het extracurriculaire onderzoeksprogramma gezien worden als een belangrijke eerste stap in de arts-onderzoekers pijplijn.

Hoofdstuk 11 is een theoretisch essay waarin we hebben geprobeerd om ons onderzoek aan theorie te koppelen en ons theoretische perspectief op de SDT uit te breiden door een raamwerk van authenticiteit toe te voegen om vroege onderzoekservaringen te vormen en welbevinden onder studenten te stimuleren. We gaan dieper in op het belang van authentieke, vroege onderzoekservaringen, gebruikmakend van de drie definities van authenticiteit zoals opgesteld door Wald en Harland: 1) 'authenticity as relating to the real world' (ofwel leren dat de echte wereld weerspiegelt), 2) 'the existential authentic self' (ofwel het ontwikkelen van een eigen identiteit en gevoel van eigenaarschap om een onafhankelijke lerende te worden) en 3) 'a degree of personal meaning' (afhankelijk van wat studenten als belangrijk zien op persoonlijk vlak). Gebaseerd op deze definities en het voorgestelde authenticiteit raamwerk, bediscussieerden we manieren om hoger onderwijs curricula op zulke manieren in te richten dat leeromgevingen inclusief zijn en welbevinden van studenten gewaarborgd worden. Dit kan bereikt worden door autonomie, competentie en verbondenheid, zoals voorgesteld door de SDT, te stimuleren en daarnaast met name te richten op sociale verbondenheid tussen studenten en mentoren en tussen studenten onderling.

In *hoofdstuk 12* hebben we geprobeerd ons onderzoek aan de praktijk te verbinden door twaalf tips voor te stellen om studenten een ervaring aan te bieden om individueel onderzoek te doen als onderdeel van het reguliere curriculum. De meeste medische opleidingen onderwijzen een groot aantal studenten op hetzelfde moment, zeker tijdens de vroege fases van het medisch onderwijs. Grootschalig onderwijs aan de ene kant en studenten de mogelijkheid bieden individueel authentieke onderzoekservaringen op te doen aan de andere kant wordt niet als makkelijk bestempeld. Daarom, voortbouwend op eigen ervaringen, bestaande literatuur en theorie, hebben we de volgende twaalf tips opgesteld om een vak te ontwikkelen en te implementeren waarin studenten authentieke, individuele onderzoekservaringen op kunnen doen binnen grootschalig onderwijs: 1) bied een ervaringsgerichte mogelijkheid aan door studenten te betrekken in elke fase van het wetenschappelijke onderzoeksproces, 2) bied authentieke onderzoekservaringen aan met data van echte patiënten en de mogelijkheid om relevante klinische vraagstukken te beantwoorden, 3) verdeel dataverzameling over alle studenten om dit haalbaar te maken binnen een kortlopend vak, 4) stimuleer nieuwsgierigheid met relevante klinische voorbeelden, 5) geef studenten autonomie in het uitvoeren van het eigen onderzoek, 6) bied onderzoekservaringen aan studenten in zowel grote als kleinere groep sessies, 7) gebruik de kleine groep sessies om het onderzoeksproces te ondersteunen, 8) gebruik inspirerende onderzoekers als docent van de kleine groep sessies, 9) implementeer 'peer discussion' binnen het vak, 10) laat studenten het werk dissemineren door een professioneel wetenschappelijk stuk te schrijven, 11) laat studenten het uiteindelijke werk mondeling presenteren, 12) includeer verschillende type toetsing en bied feedback op zowel het verslag als de presentatie.

In *hoofdstuk 13* reflecteren we op de bevindingen van de verschillende studies om op die manier inzicht te bieden in de mogelijke impact van een focus op vroege fases van de medische opleiding om arts-onderzoekers te kweken. We gaan dieper in op de rol van bewustzijn en intrinsieke motivatie voor onderzoek, waarbij we bespreken dat om jonge medische studenten te stimuleren de mogelijkheid voor een carrière als een arts-onderzoeker te erkennen, en dit na te jagen, onze studies tezamen suggereren dat drie overstijgende thema's een belangrijke rol spelen: bewustzijn, motivatie en mogelijkheid. Aangezien onze resultaten lieten zien dat zelfs eerstejaarsstudenten zich al bewust zijn van het belang van onderzoek voor de klinische praktijk en deze studenten gemotiveerd voor onderzoek aan de medische opleiding beginnen, geloven we dat in lijn met de titel van dit proefschrift studenten inderdaad 'jong gevangen kunnen worden'. Daarnaast gaan we ook dieper in op manieren om intrinsieke motivatie voor onderzoek te stimuleren, de rol van extracurriculaire onderzoeksprogramma's binnen het medisch onderwijs (ofwel de 'mogelijkheid') en het dynamische karakter van motivatie voor onderzoek, op basis van bestaande theoretische perspectieven en onze onderzoeksbevindingen. Dit resulteert in praktische implicaties voor het medisch onderwijs in het algemeen en praktische implicaties voor het blootstellen van studenten aan onderzoekservaringen. Praktische implicaties voor het medisch onderwijs in het algemeen zijn: 1) verbind onderzoek en praktijk, 2) stel studenten bloot aan inspirerende wetenschappelijke rolmodellen, 3) stimuleer nieuwsgierigheid onder studenten, 4) identificeer studenten met een behoefte aan extra uitdaging en 5) stel studenten bloot aan onderzoekservaringen tijdens vroege fases van de medische opleiding. Naast de twaalf tips opgesteld in het twaalfde hoofdstuk, zijn praktische implicaties om studenten bloot te stellen aan onderzoekservaringen: 1) bied studenten de mogelijkheid om aan eigen onderzoek gerelateerde leerdoelen te werken en onderzoeksactiviteiten onder de knie te krijgen, 2) maak extracurriculaire initiatieven breed toegankelijk voor medische studenten vroeg in de medische opleiding, 3) pak onrealistische percepties van onderzoek aan, 4) laat studenten statistiek toepassen op authentieke onderzoeksvragen, 5) laat studenten autonomie ervaren en de mogelijkheid om zelfstandig te werken, 6) bied studenten mogelijkheden om te leren van en terug te vallen op een ervaren mentor in onderzoek, 7) stimuleer gevoelens van sociale verbondenheid en tot slot 8) implementeer authentieke toetsing van studenten binnen onderzoek gerelateerde vakken.

Supplements

Overview

Appendix A: Interview guide used within our qualitative study

Interview guide exists out of 3 topics: background, perceptions of research, and motivation for research. These three subjects will be discussed within the interview. The topics are comprised of numbered questions, which will be asked to start the interview and discussion with the individual students. The sub-questions will only be used when a student does not seem to understand the questions or does not know what to answer (which almost never occurred during the actual interviews).

1: Background

1. What is your educational background?
2. Why did you choose Medicine?
3. Do you have previous experiences with research? If yes, could you elaborate?

2: Perceptions of research

1. How do you perceive conducting research?

Sub-question:

- *What are the activities of a researcher?*
- *What are the abilities you should have to perform research?*
- *What can you do with research?*
- *For whom is research important?*

2. To which extent do you believe that research can be used as a physician? And in what way do you think physicians can use research?

Sub-question:

- *Should physicians use research in clinical practice?*
- *Should physicians conduct research?*

3: Motivation for research

1. Are you planning to conduct research yourself?

If yes:
What motivates you to conduct research?

If no:
What demotivates you to conduct research?

If unknown:
Ask what could motivate or demotivate to conduct research hypothetically

2. Elaborating on the counterpart of the first question

Appendix B: Overview of all emerged themes and sub-themes within our qualitative study

Themes		Sub-themes	
1	Research processes	*1.1*	Create research questions
		1.2	Come up with methods
		1.3	Gather data
		1.4	Process data
		1.5	Create results
		1.6	Draw conclusions
		1.7	Report
2	Research goals	*2.1*	Create new knowledge or refine existing knowledge
		2.2	Solve problems
		2.3	Answer questions
		2.4	Find a given fact or pattern
		2.5	Progress in science and healthcare
		2.6	Development and improvement of medicines
		2.7	Development and improvement of illness treatment
		2.8	Better physicians
		2.9	Improve work experience of physicians
		2.10	Improve patient experience and trust
		2.11	Improve organisation within the hospital
		2.12	Intellectual development of physician-scientist
		2.13	Prestigious for the career development of the physician-scientist
		2.14	Improve education
3	Research characteristics	*3.1*	Hard
		3.2	Detailed and careful
		3.3	Intensive
		3.4	Challenging
		3.5	Large scaled
		3.6	Useful
		3.7	Additional obligations
		3.8	Unilateral work environment
4	Research topics	*4.1*	Healthcare
		4.2	Prevention
		4.3	Organizational
5	Research requirements	*5.1*	Collaboration
		5.2	Finance
		5.3	Ethical approval

Themes	Sub-themes
6 Motivating factors	*6.1* Personal development
	6.2 Acknowledgment or rewards
	6.3 Contributing to knowledge or patient care
	6.4 Curiosity
	6.5 Different fun parts of conducting research
	6.6 Variety
	6.7 Ability to work independently
	6.8 Topic
	6.9 Opportunity to network
	6.10 Possibilities to conduct research available
	6.11 Research orientation
	6.12 Collaboration
	6.13 Inspiring role models
	6.14 Need for extra challenge
7 Demotivating factors	*7.1* Content
	7.2 Other priorities
	7.3 Lack of time
	7.4 Mental pressure
	7.5 Lack of support
	7.6 Inadequate atmosphere or collaboration
	7.7 Lack of or disappointing results
	7.8 Lack of contribution
	7.9 Difficulty
	7.10 Gathering and processing of data
	7.11 Statistics
	7.12 Less attractive than clinical practice
	7.13 Lack of autonomy
	7.14 Misfit with personality

Appendix C: Questionnaire used within our studies

Students received the instruction to score items on a 7-point Likert scale, defined as:
1 'totally disagree' – 7 'totally agree'.

Intrinsic motivation for research

1. Doing research is interesting
2. Doing research is fun
3. Doing research is challenging
4. I like solving puzzles and problems
5. I am able to develop myself by doing research

Extrinsic motivation for research

6. I think that doing research is useful for my resume
7. I think that doing research could help me to distinguish myself from others
8. I think that doing research could help me to get a good job in the future
9. I think that doing research improves my chances for my preferred residency spot

Research self-efficacy

10. I feel I am good in doing research
11. I feel I am competent enough to do research
12. I feel I master the skills to do research

Perceptions of research

13. It is important for medical professionals to have scientific skills
14. A scientific educational programme is important for me
15. I enjoy the attention paid to science in this educational programme
16. Medical education should be scientific
17. A doctor should be able to independently do research

Curiosity

18. I enjoy exploring new ideas
19. Difficult conceptual problems can keep me awake all night thinking about solutions
20. I enjoy learning about subjects that are unfamiliar to me
21. I can spend hours on a single problem because I just can't rest without knowing the answer

22. I find it fascinating to learn new information
23. I feel frustrated if I can't figure out the solution to a problem, so I work even harder to solve it
24. When I learn something new, I would like to find out more about it
25. I brood for a long time in an attempt to solve some fundamental problem
26. I enjoy discussing abstract concepts
27. I work like a fiend at problems that I feel must be solved

List of scientific contributions

Scientific publications

BWC Ommering, FM van Blankenstein, M van Diepen & FW Dekker (2021). Academic success experiences: promoting research motivation and self-efficacy beliefs among medical students. *Teaching and Learning in Medicine*. Epub ahead of print. DOI: 10.1080/10401334.2021.1877713

M Versteeg, G Bressers, M Wijnen – Meijer, **BWC Ommering**, AJ de Beaufort & P Steendijk (2021). What were you thinking? Medical students' metacognition and perceptions of self-regulated learning. *Teaching and Learning in Medicine*. Epub ahead of print. DOI: 10.1080/10401334.2021.1889559

BWC Ommering, M Wijnen – Meijer, DHJM Dolmans, FW Dekker & FM van Blankenstein (2020). Promoting positive perceptions of and motivation for research among undergraduate medical students to stimulate future research involvement: a grounded theory study. *BMC Medical Education, 20(1),* 204. DOI: 10.1186/s12909-020-02112-6

BWC Ommering, M van Diepen, FM van Blankenstein, PGM de Jong & FW Dekker (2020). Twelve tips to offer a short authentic and experiential individual research opportunity to a large group of undergraduate students. *Medical Teacher, 42(10),* 1128-1133. DOI: 10.1080/0142159x.2019.1695766

M Versteeg, RA Hendriks, A Thomas, **BWC Ommering** & P Steendijk (2019). Conceptualising spaced learning in health professions education: a scoping review. *Medical Education, 54(3),* 205-216. DOI: 10.1111/medu.14025

CJF Waaijer, **BWC Ommering**, LJ van der Wurff, TN van Leeuwen, FW Dekker & NVMO Special Interest Group on Scientific Education (2019). Scientific activity by medical students: the relationship between academic publishing during medical school and publication careers after graduation. *Perspectives on Medical Education, 8,* 223-229. DOI: 10.1007/s40037-019-0524-3

BWC Ommering, FM van Blankenstein, M Wijnen – Meijer, M van Diepen & FW Dekker (2019). Fostering the physician-scientist workforce: a prospective cohort study to investigate the effect of undergraduate medical students' motivation for research on actual research involvement. *BMJ Open, 9(7),* e028034. DOI: 10.1136/bmjopen-2018-028034

BWC Ommering, FM van Blankenstein, CJF Waaijer & FW Dekker (2018). Future physician-scientists: could we catch them young? Factors influencing intrinsic and extrinsic motivation for research among first-year medical students. *Perspectives on Medical Education, 7,* 248-255. DOI: 10.1007/s40037-018-0440-y

BWC Ommering, PJ van den Elsen, J van der Zee, CR Jost & FW Dekker (2018). Using an extracurricular Honors program to engage future physicians into scientific research in early stages of medical training. *Medical Science Educator, 28,* 451-455. DOI: 10.1007/s40670-018-0565-y

BWC Ommering & FW Dekker (2017). Medical students' intrinsic versus extrinsic motivation to engage in research as preparation for residency. *Perspectives on Medical Education, 6,* 366-368. DOI: 10.1007/s40037-017-0388-3

Book chapter

BWC Ommering, A Haramati & PGM de Jong (2021). Teaching to develop scientific engagement in medical students. In KN Huggett, KM Quesnelle & WB Jeffries (Eds). *An Introduction to Medical Teaching: The Foundations of Curriculum Design, Delivery, and Assessment,* Third Edition.

Manuscripts under review

BWC Ommering, FM van Blankenstein, M van Diepen, NA Gruis, A Kool & FW Dekker (2021). The importance of motivation in selecting undergraduate medical students for extracurricular research programmes.

BWC Ommering, FM van Blankenstein & FW Dekker (2021). First steps in the physician-scientist pipeline: a longitudinal study to examine the effects of an undergraduate extracurricular research programme.

H Walkington & **BWC Ommering** (2021). How does engaging in authentic research at undergraduate level contribute to student wellbeing?

JT van der Steen, WH Tong, J Groothuijse & **BWC Ommering** (2021). Perceptions and motivation concerning research and evidence-based medicine education in Elderly Care Medicine.

Paper presentations

Year	Title	Conference
2020	De rol van succeservaringen in het stimuleren van intrinsieke motivatie voor en self-efficacy gevoelens over onderzoek bij bachelorstudenten Geneeskunde	Netherlands Association of Medical Education
2020	A good start is half the battle: the effect of motivation for research at the start of medical training on actual research involvement	International Association of Medical Education
2019	Een goed begin is het halve werk: het effect van motivatie voor onderzoek aan het begin van de studie op daadwerkelijke betrokkenheid bij onderzoek	Netherlands Association of Medical Education
2019	Cultivating future researchers: motivating students for research as a first step towards success?	European Association for Research on Learning and Instruction
2019	Fostering the scientific workforce: the effect of undergraduate students' motivation for research on actual research involvement	Higher Education Conference
2018	Higher education as a breeding ground for future researchers: a grounded theory study focusing on perceptions of and motivation for research among first-year medical students	Society for Research into Higher Education
2018	Fostering the scientific workforce: motivating students for research as a first step towards success	Society for Research into Higher Education
2018	De bachelor Geneeskunde als kweekvijver voor arts-onderzoekers: een grounded theory studie gericht op percepties van en motivatie voor onderzoek onder eerstejaarsstudenten	Netherlands Association of Medical Education
2018	Motivation for research among first-year medical students: intrinsic versus extrinsic motivation and factors of influence?	European Association for Research on Learning and Instruction
2017	Motivatie voor onderzoek bij de beginnende medische student: hoe is de motivatie opgebouwd en welke factoren beïnvloeden deze motivatie?	Netherlands Association of Medical Education

Poster presentations

Year	Title	Conference
2017	Factors influencing motivation for research among first-year medical students: how can we direct students towards a research oriented career?	International Association of Medical Education
2017	Students' incentives to participate and their development in a research oriented bachelor Honours Programme	National Honours Expert Meeting

Round tables / workshops

Year	Title	Conference
2019	Dilemma's rondom het begeleiden en beoordelen van een wetenschapsstage	Netherlands Association of Medical Education meeting
2019	Diepgang en Praktijk van het Medische Statistiek Onderwijs: moeilijk doen kan altijd nog	Netherlands Association of Medical Education
2019	Leren voor de toets? Zo 20e eeuw! Inzetten op motivatie: hoe we het 'moeten' wat makkelijker kunnen maken	LUMC LEARN meeting
2019	Leren voor de toets? Zo 20e eeuw! Inzetten op motivatie: hoe we het 'moeten' wat makkelijker kunnen maken	Interfacultair Medisch Studentenoverleg Congres
2018	Dilemma's rondom het begeleiden en beoordelen van een onderzoeksstage: focus op eindproduct of op leerproces?	Netherlands Association of Medical Education
2018	Leren voor de toets? Zo 20e eeuw! Inzetten op motivatie: hoe we het 'moeten' wat makkelijker kunnen maken	LUMC Onderwijsconferentie
2017	Dé Honoursstudenten: wie zijn ze, wat kunnen ze en wat willen ze?	Netherlands Association of Medical Education

Awards and nominations

Year	Title	Conference
2019	Een goed begin is het halve werk: het effect van motivatie voor onderzoek aan het begin van de studie op daadwerkelijke betrokkenheid bij onderzoek	Netherlands Association of Medical Education *(nominated for best research paper prize)*
2018	De bachelor Geneeskunde als kweekvijver voor arts-onderzoekers: een grounded theory studie gericht op percepties van en motivatie voor onderzoek onder eerstejaarsstudenten	Netherlands Association of Medical Education *(nominated for best research paper prize)*
2017	Motivatie voor onderzoek bij de beginnende medische student: hoe is de motivatie opgebouwd en welke factoren beïnvloeden deze motivatie?	Netherlands Association of Medical Education *(awarded best research paper prize)*

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Curriculum Vitae

Belinda Ommering was born on the 23th of December 1990 in Vlaardingen, the Netherlands. After completing secondary education at Vos Lyceum in 2009, she received her bachelor's degree in Pedagogical Sciences from Leiden University in 2012. In 2013, Belinda obtained her master's degree in Child and Family studies at Leiden University. As part of her master's degree, she conducted research focusing on parenting in second generation Turkish families, resulting in a master's thesis on the relationship between acculturation (i.e. host language proficiency), perceived discrimination, and parenting self-efficacy in second generation Turkish mothers in the Netherlands. Hereafter, Belinda started working as a junior researcher at the University of Amsterdam and Kohnstamm Institute, focusing on improving the quality of centre-based child care and family day care. In 2016, Belinda started her PhD research at the Center for Innovation in Medical Education at Leiden University Medical Center, under supervision of prof. dr. Friedo Dekker. In her PhD project, Belinda's research focused on motivating undergraduate medical students to engage in research both during the regular courses of undergraduate medical training as well as during an extracurricular research programme. She presented her research at national and international conferences. In 2017, Belinda won the 'best research paper award' at the conference of the Netherlands Association of Medical Education (NVMO), and she was nominated for that same award in both 2018 and 2019. Besides her research activities, Belinda is actively involved within the NVMO expert group on academic and scientific training, since 2018 she serves as secretary within this group. Furthermore, Belinda is involved in teaching students about research during the Medicine bachelor as well as supervising bachelor and master Medicine students in conducting research.