Future physician-scientists: let's catch them young! unravelling the role of motivation for research

Ommering, B.W.C.

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.