

Benefits and pitfalls of scientific research during undergraduate medical education

Nutzen und Stolpersteine wissenschaftlicher Forschung in der hochschulmedizinischen Ausbildung

Abstract

Objective: The integration of scientific research into medical education is a widely discussed topic. Most research training programs are offered on a voluntary basis. In Germany, it is mandatory to complete a doctoral thesis to obtain the academic title "doctor". The reasons why students start a dissertation project and the influence of this project on their undergraduate studies and later career choices are not well known.

Method: This study was conducted at five German universities in 2003, with a total of 437 fifth-year students participating in it. A standardised questionnaire was used to ask participants about their current or finished dissertation (group A), a dissertation they had discontinued (group B) or why they had never started a dissertation project (group C).

Results: The two most important reasons for students from group A to start a dissertation were "interest in the topic" and "advantage for job applications". Compared with group B, they mentioned "improved ability to critically appraise scientific studies" and "doing scientific work independently" significantly more often as a result of working on their dissertation. Starting a dissertation project early during undergraduate studies was correlated with a less successful outcome. Moreover, working on a dissertation significantly reduced time spent on undergraduate studies. Students from group C named the "workload of undergraduate studies" and "no time" most frequently as reasons for not having started a dissertation.

Conclusion: Students who have been working successfully on a dissertation rate items regarding the acquisition of scientific research skills significantly more positively, and participation in undergraduate studies seems to be negatively affected by working on a dissertation project. Therefore, basic training in scientific research methodology should become an integrated part of the medical undergraduate curriculum, while special programs should be offered for students with a particular interest in scientific research programs or an academic career.

Keywords: medical research, scientific work, medical education, dissertation, doctorate

Zusammenfassung

Hintergrund: Über die Integration wissenschaftlicher Forschung in die hochschulmedizinische Ausbildung wird viel diskutiert. Die meisten Trainingsprogramme für wissenschaftlich interessierte Studierende finden auf freiwilliger Basis statt. In Deutschland ist das Schreiben einer Doktorarbeit erforderlich, um den Titel "Dr. med." zu führen. Die Gründe, warum Studierende eine Dissertation beginnen und welchen Einfluss ihr wissenschaftliches Projekt auf den Verlauf des Studiums und die spätere Berufswahl haben, sind nur unzureichend untersucht.

Methoden: Die Studie wurde an fünf deutschen Universitäten im Jahre 2003 durchgeführt. Insgesamt nahmen 467 Studierende des fünften Studienjahres daran teil. Mit Hilfe eines standardisierten Fragebogens

Olaf Kuhnigk^{1,2}
Aenne M. Böthern²
Jens Reimer¹
Ingo Schäfer¹
Astrid Biegler³
Markus Jueptner⁴
Mathias Gelderblom⁵
Sigrid Harendza⁶

1 Universitätsklinikum
Hamburg-Eppendorf, Klinik
und Poliklinik für Psychiatrie
und Psychotherapie,
Hamburg, Deutschland

2 Universitätsklinikum
Hamburg-Eppendorf,
Prodekanat für Lehre,
Hamburg, Deutschland

3 Integrierte Psychiatrie
Winterthur,
Gerontopsychiatrisches
Ambulatorium, Winterthur,
Schweiz

4 Rheinische Kliniken Essen,
Klinik für Psychiatrie und
Psychotherapie, Essen,
Deutschland

5 Universitätsklinikum
Hamburg-Eppendorf, Klinik
für Neurologie, Hamburg,
Deutschland

6 Universitätsklinikum
Hamburg-Eppendorf, III.
Medizinische Klinik,
Hamburg, Deutschland

wurden die Teilnehmer über ihre aktuelle oder bereits abgeschlossene Dissertation (Gruppe A) oder ein abgebrochenes Dissertationsprojekt (Gruppe B) befragt. Studierende, die kein Dissertationsprojekt begonnen hatten, wurden über die Gründe hierzu befragt (Gruppe C).

Ergebnisse: Die beiden Hauptgründe für Studierende der Gruppe A eine Dissertation zu beginnen waren "Interesse am Thema" und "Vorteile bei späteren Bewerbungen". Im Vergleich zur Gruppe B wurden verbesserte Fähigkeiten sich "kritisch mit den Methoden wissenschaftlicher Studien auseinander zu setzen" und "eigenständiges wissenschaftliches Arbeiten" signifikant häufiger als Resultat der Beschäftigung mit der Dissertation von Studierenden der Gruppe A genannt. Ein Beginn der Promotion in frühen Studienjahren korrelierte mit einem schlechteren Erfolg der Dissertation. Weiterhin reduzierte die Arbeit an einer Dissertation signifikant die Zeit, die für das Studium aufgewendet wurde. Studierende der Gruppe C nannten die Arbeitsbelastung im Studium und "keine Zeit" als die häufigsten Gründe für den Nichtbeginn einer Dissertation.

Schlussfolgerung: Studierende, die erfolgreich eine Dissertation abgeschlossen haben oder noch an ihr arbeiten, beurteilen die Möglichkeit, sich wissenschaftliche Fähig- und Fertigkeiten angeeignet zu haben, als signifikant positiver. Die Teilnahme an Lehrveranstaltungen des Studiums scheint negativ durch die Arbeit an einer Dissertation beeinflusst zu werden. Deswegen sollte eine grundlegende wissenschaftliche Ausbildung integraler Bestandteil des medizinischen Curriculums sein. Spezielle Programme sollten für Studierende mit einem spezifischen Interesse an wissenschaftlichen Programmen oder mit Interesse an einer akademischen Laufbahn angeboten werden.

Schlüsselwörter: medizinische Forschung, wissenschaftliches Arbeiten, medizinische Ausbildung, Dissertation

Introduction

When and how scientific research should be integrated into medical education is a widely discussed topic [1]. From the perspective of medical educators research training should provide a rich and rewarding period of learning with respect to critical thinking, reviewing and interpreting the literature, experimental design, interpreting data, and communication [2]. Many countries offer scientific research programs during medical residency or fellowships with variable success [3], [4]. Only a minority of trainees had completed a thesis [3]. Many trainees made adverse comments on the program [5]. There were also indications of inadequate training [6]. Some trainees, however, mentioned the value of having protected time for research [7]. An increase in future research activity was noted with longer duration of programs [8]. One study even found that more than 80% of trainees on a research program became academics [9].

Research training programs have also been offered to medical students on a voluntary basis and seem to have an important impact on medical students' research careers [10]. Furthermore, medical students showed an interest in scientific research electives [11] and research summer schools [12]. Other quite successful approaches have been made by curricular integration of basic sciences into clinical medicine [13]. Following one successful medical research project at the Albert Einstein College of Medicine in New York, which showed great improve-

ment in students' scientific research skills, the question was even raised whether research projects should be a requirement for medical school graduation [14]. However, data from another study showed that a break to pursue research between year two and three of medical undergraduate training was associated with lower grades and scores on clinical knowledge tests [15].

The World Federation for Medical Education [16] suggests in its "Standards for quality improvement in medical education – European specifications" that the interaction between research and education activities should be reflected in the undergraduate curriculum and should encourage and prepare students to engage in medical research and development [16]. It also proposes that training in scientific thinking and research methods may include the use of elective research projects to be conducted by medical students [16]. However, many German medical students start working on a scientific research project during their undergraduate studies to write a dissertation which is reviewed and marked by two or three professors and is required to obtain the title "Dr. med." after successful graduation from medical school.

The reasons why and when medical students in Germany decide to start working on a dissertation and the influence that a completed or abandoned research project has on their undergraduate studies are currently not well known. One study revealed that more than 15% of medical students never planned to start a dissertation project during their undergraduate training, while other studies from

individual universities showed that up to 21% of all students abandoned at least one research project [17], [18]. There is an ongoing discussion whether scientific research should be an integrated part of undergraduate medical training and not connected with receiving the academic title "Dr. med." On the other hand, students who want to pursue academic medicine could be given the opportunity to work in elective or postgraduate scientific research programs.

Therefore, the aims of this study were to evaluate students' reasons for starting or not starting a dissertation research project. The influence of working on a research project on the pursuit of undergraduate studies was evaluated at five German universities. On the basis of the results from the students' questionnaires and the literature, we propose a model to study and conduct scientific research in medical education.

Methods

Sample and Design

In summer 2003, $N=467$ students at five German universities were included in this study (questionnaires distributed/collected: Berlin: 57/52; Bochum: 90/88; Düsseldorf: 132/112; Essen 70/68; and Hamburg: 118/117). The participation was anonymous and optional and took place during compulsory courses, hence numbers of distributed questionnaires were used as equivalents for numbers of enrolled students per semester.

Participants were studying in semester nine at this time, only in Bochum students were given the questionnaire in semester eight (the total number for undergraduate training in Germany is twelve semesters with semesters 11 and 12 being the "practical year" with full-time work on the wards or in ambulatory care). The data were collected and handled in accordance with the Data Protection Act. The vice deans of education and the directors of the departments agreed to this study. Return rates of questionnaires were between 85% and 99%. The data from all universities were combined for statistical analysis.

Assessment

A questionnaire was designed based on published data regarding dissertations [19], [20] and on questions designed by the authors with regard to the literature. The instrument included the following categories:

1. General questions about the dissertation, scientific work, and relevant personality traits (completed by all participants; 8 questions)
2. Questions about the current or finished dissertation, e.g., type of project, reasons for choosing this project, accomplishment of individual project steps, expenditure of time for the project, and influence on undergraduate studying, as well as problems with the project (36 questions)

3. Questions about the first discontinued dissertation; questions similar to group A were asked (37 questions)
4. Questions for students who had never started a dissertation project, asking for their reasons for not starting (2 questions)
5. General social background (completed by all participants; 6 questions)

The response options included dichotomous yes/no-type answers (e.g., did you start your dissertation during your undergraduate studies?), numeral statements (e.g., number of semesters), individual text (e.g., "reasons were: please specify") and approval or refusal of a statement on a 6-point Likert scale ("1= I strongly agree", "2= I agree", "3= I moderately agree", "4= I moderately disagree", "5= I disagree", "6= I strongly disagree").

Statistical Analysis

Data were evaluated in three groups.

- Group A: students with an ongoing or finished dissertation.
- Group B: students with discontinued dissertation projects.
- Group C: students who had never started a dissertation.

Data are presented as arithmetic means and frequency distributions. The X^2 distribution test and the t -test were used as statistical tests for independent samples.

All discontinued dissertations were combined, even if a student started a new dissertation in the meantime. In this case, students were part of both groups answering the respective questions. Nevertheless, the t -test for independent samples was chosen because it reacts robustly against violations of its premises and is more conservative than the t -test for related samples. As our study was designed to collect data to propose suggestions for further research in this field, no Bonferroni correction was used to avoid an alpha error. Effect sizes are shown where appropriate, with values of 0.2 indicating small effects and values of 0.8 indicating large effects [21]. SPSS was used for all statistical analyses.

Results

437 of the 467 students participating in this study returned their questionnaire, resulting in a 93.5% return rate. A total number of 327 students had finished a dissertation or had started at least one dissertation and were still working on it (group A), 65 had abandoned at least one dissertation (group B), and 92 had never started a dissertation project (group C).

The two most important reasons why students from group A started a dissertation were "interest in the topic" and "advantage for job applications", while "because everybody does a dissertation" reached the lowest rank (see Figure 1).

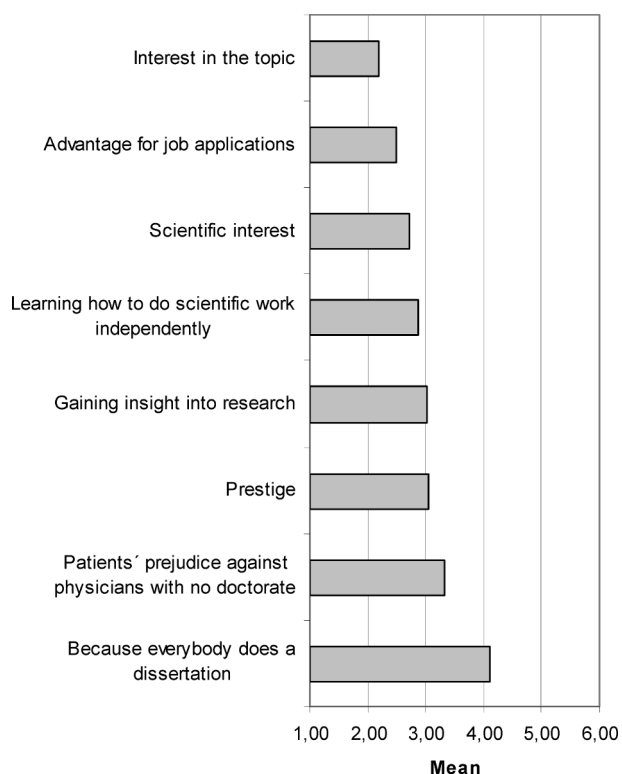


Figure 1: Reasons why students started a particular dissertation project

When asked about the advantages they gained from working on their dissertation project, students from group A most frequently named “improved ability to critically appraise scientific studies” and “doing scientific work independently” as the biggest gains (see Figure 2). These and all other items (all means < 3.0) were significantly different from group B ($P < 0.001$, $\epsilon = 0.43-0.62$). Neither students from group A nor students from group B felt that a dissertation was a “useful addition to medical undergraduate studies”.

Almost 23% from group A and 8.3% from group B stated that working on a dissertation project had increased the duration of their undergraduate studies ($P < 0.05$). Students from group A also reduced their participation in lectures and their preparation for and participation in courses significantly more than students from group B ($P < 0.001$). Studying time for exams was influenced less by working on a dissertation (group A: $M = 3.71$, $SD = 1.87$; group B: $M = 4.26$, $SD = 1.93$, $\epsilon = 0.29$) but still significantly more reduced in group A compared with group B ($P < 0.001$). From group A, 32.4% of the students estimated that working on their dissertation represented between 20% and 50% of the total time they used for their clinical studies (years 3 to 6), while 41.0% from group B spent only up to 5% of time for their clinical studies on their dissertation.

The choice of dissertation topic had a significantly greater influence on the choice of speciality in postgraduate training in group A (33.0%) compared with group B (8.1%, $P < 0.001$). When asked whether they believed that medical students were trained to work scientifically during their undergraduate studies and whether they felt that a

dissertation increased the qualification of a graduate to work as a physician, students from all three groups answered these questions negatively (all means > 4.1, no significant group differences). Only 30.4% from group A but 66.2% from group B had started their dissertation project before the end of year 3 of their undergraduate training ($P < 0.001$).

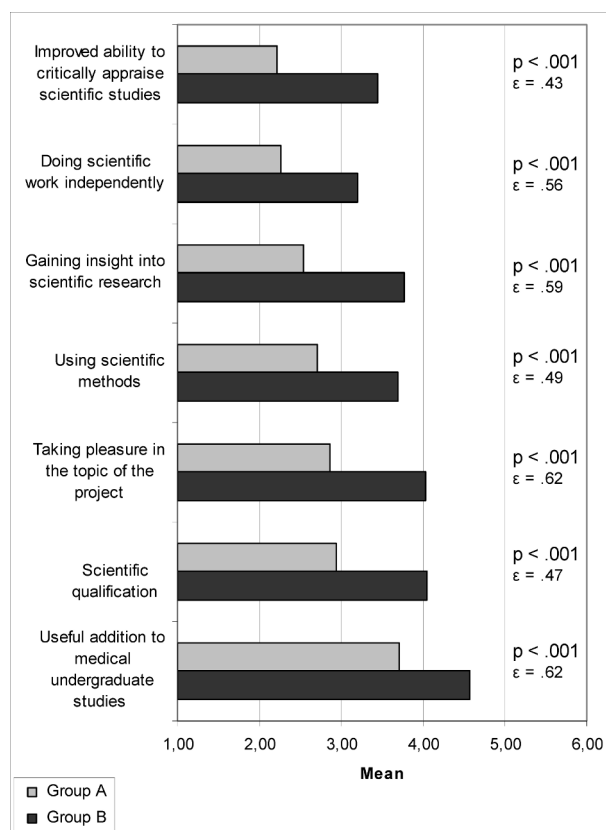


Figure 2: Advantages which students gained from working on their dissertations

Students from group C named “working on a dissertation distracts me from my undergraduate studies” ($M = 2.54$, $SD = 1.34$) and “no time” ($M = 2.54$, $SD = 1.60$) as the most frequent reasons for not having started a dissertation (see Figure 3). They also found that “a dissertation is no additional qualification for working as a physician” ($M = 3.16$, $SD = 1.75$). Other items did not seem to have played a major role in the decision against starting a dissertation.

When students were asked whether they would have started a dissertation for scientific qualification if the title “Dr. med.” was given just with graduation, 66% of the students who had never abandoned a dissertation project and 82.0% of the students who had never started a dissertation project answered with “no”.

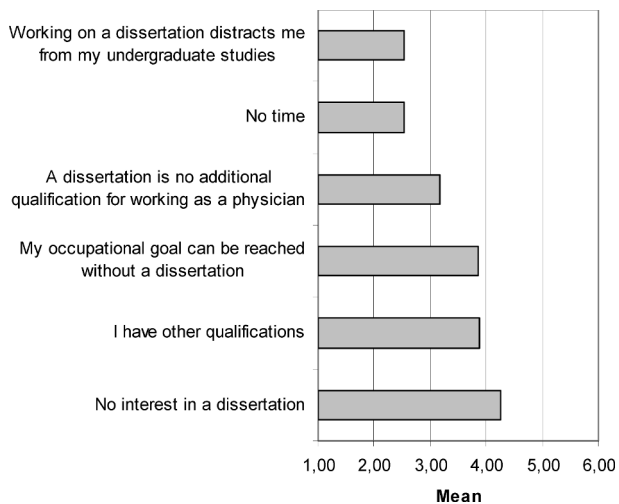


Figure 3: Reasons for not having started a dissertation project

Discussion

According to our data, students decide to work on a dissertation for two main reasons: “interest in the topic” and “advantage for job applications”. Both items represent important aspects of a career in scientific research, either as a prerequisite for research success [22] or to open up career choices [23]. Therefore it seems almost natural that they are on top of the list for dissertation research projects as well. Whether these initial expectations are fulfilled and how working on a dissertation influences medical undergraduate studies is another matter. While students from group A feel that they developed their abilities to critically appraise scientific studies and learned to do scientific work independently while pursuing a dissertation project, they are less convinced that a dissertation is an advantage for a scientific qualification or a useful addition to medical undergraduate studies. Students from group B who abandoned at least one dissertation are even significantly less convinced about the latter. The above-mentioned findings referring to the development of scientific abilities are supported by other studies which show successful outcomes of research training on a voluntary basis [11] – currently the dissertation in Germany is a voluntary project. On the other hand, it has also been demonstrated that medical research can successfully be integrated into the curriculum [14]. Hence, the question arises whether timeframe, structure, and content might be the important components for students to experience research successfully. Since meanwhile the Bologna process is under way and may become an option for German medical schools, the dissertation will be part of its third cycle and take place after graduation from medical school.

In our study students claimed that working on their dissertation had increased the duration of their undergraduate studies and it required up to 50% of their studying time during the clinical years. This also led to a reduction in their participation in lectures and other courses. These negative influences on undergraduate studies were signi-

ficantly greater in students from group A who had successfully finished a dissertation or were still working on it. Students from group C who had never started a dissertation used the same arguments “working on a dissertation distracts me from my undergraduate studies” and “no time” as reasons for not wanting to start a dissertation. They were not asked whether they had their lectures and courses in due time, which can be regarded as a reduction of the informative value of this statement. Since another study demonstrated that a break during undergraduate studies to pursue research was associated with lower grades on clinical knowledge tests [15], it may be of some concern that – according to our data – working on a dissertation during undergraduate training might have the same consequences. However, these data were obtained with a curriculum where medical school takes only three years, and with the new legislation of the licensure law in Germany that came into effect after this study was conducted, our data on participation in lectures and seminars have to be seen from a different perspective. Nevertheless, our study also shows that the later students start working on their dissertation, the more frequently the outcome of their research project seems to be successful. This leads to the hypothesis that some knowledge on research is acquired during undergraduate medical studies even though no structured program exists so far. On the other hand, it could also be possible that an unknown number of students who started their dissertation in higher semesters might abandon their project later and were not detected in our study. However, our data show that many students seem to have great interest in scientific research, and other studies have also revealed that knowledge in scientific research is important in clinical medicine [2]. But a majority of students from our study would also not have started a dissertation if the academic title “Dr. med.” had been bestowed upon graduation like the title MD. On the other hand, if research training programs are successful they can open up the chance for an academic career [9].

Basic knowledge in scientific research is an important prerequisite for the practicing physician [2] and can be successfully integrated into undergraduate medical training [13], [14], [24]. Hence, it seems reasonable to suggest that basic knowledge in scientific research should be integrated into the medical undergraduate curriculum as proposed by the WFME [16]. Our data show that many students had a particular interest in scientific research but would not necessarily have started a dissertation if the title “Dr. med.” had been conferred upon graduation. Also, students who abandoned a dissertation might have had more benefit from a mandatory basic scientific research program than from an unsuccessful dissertation project as far as the attainment of scientific research skills is concerned. Students showing an additional particular interest in scientific research could be given the opportunity to broaden their skills and knowledge in scientific research by doing research electives [11], [12], which also seem to be quite successful in recruiting future researchers [9]. Since many countries provide research

time during residency or fellowships with only a minority of trainees completing a thesis [3] but a majority of participants valuing protected time for research in these programs [7], according to our data it might seem appropriate to integrate protected research time on a voluntary or elective basis into undergraduate studies for students having a special interest in this field. The fact that students from group A and B felt that the dissertation in its current form is not a useful addition to medical undergraduate studies underscores this proposal.

In summary, our data show that students choose a dissertation project because of being interested in the topic and because of hoping that a dissertation is an advantage during job application. Students working on a dissertation successfully rate all items regarding the acquisition of scientific research skills significantly more positively than students who abandoned a dissertation project. Starting early during undergraduate studies with this voluntary project is associated with a more unsuccessful outcome. In the light of our data and regarding results of other studies, we propose the following approach to scientific research for medical students:

- Training in scientific thinking and research methodology, especially interpreting the literature, experimental design, and data interpretation should become an integrated part of the medical undergraduate curriculum.
- Scientific research electives or summer courses should be offered as part of the medical undergraduate mandatory elective program for students with a special interest in research projects which could be further pursued in PhD programs and research programs at medical faculties.

Contributions

OK and MJ designed the study. AB collected and computerized the data under the supervision of OK. All authors were involved in the data analysis and in writing the manuscript.

Funding

The study was not funded.

Acknowledgements

The authors thank the vice-deans of education and the directors of the participating departments of the five universities for allowing us to distribute the questionnaires during students' courses. We especially thank all medical students for their participation in the study.

Ethical approval

The ethics committee of the University Essen-Duisburg was requested for permission of this study. Since students participated in this study voluntarily and anonymously the ethics committee stated that no special approval needed to be given.

Competing interests

The authors declare that they have no competing interests.

References

1. Barton JR. Academic training schemes reviewed: implications for the future development of our researchers and educators. *Med Educ.* 2008;42(2):164-169. DOI: 10.1111/j.1365-2923.2007.02978.x
2. Cope AP, Brennan FM, Hill Gaston JS, Haskard DO. Planning your research training. *Rheumatology (Oxford).* 2005;44(11):1339-1340. DOI: 10.1093/rheumatology/kei098
3. Ríos Zambudio A, Sánchez Gascón F, Gonzáles Moro L, Guerrero Fernández M. Research training during medical residency (MIR). Satisfaction questionnaire. *Rev Esp Enferm Dig.* 2004;96(10):695-704.
4. Löwe B, Hartmann M, Wild B, Nikendei C, Kroenke K, Niehoff D, Henningsen P, Zipfel S, Herzog W. Effectiveness of a 1-year resident training program in clinical research: a controlled before-and-after study. *J Gen Intern Med.* 2008;23(2):122-128. DOI: 10.1007/s11606-007-0397-8
5. Neale G. The place of research in the training of a physician. *J R Coll Physicians Lond.* 1991;25(4):188-190.
6. Fasser CE, Smith QW, Luchi RJ. Geriatrics fellows' perceptions of the quality of their research training. *Acad Med.* 1992;67(10):696-698. DOI: 10.1097/00001888-199210000-00017
7. De Lisa JA, Jain SS, Kirshblum S. Physiatric research fellows' perceptions of the quality of their training. *Am J Phys Med Rehabil.* 1998;77(5):412-414. DOI: 10.1097/00002060-199809000-00009
8. Thakur A, Thakur V, Fonkalsrud EW, Singh S, Buchmiller TL. The outcome of research training during surgical residency. *J Surg Res.* 2000;90(1):10-12. DOI: 10.1006/jsre.2000.5817
9. Beck IT, Depew WT. Canadian research fellowship training programs in digestive sciences: achievements and challenges. *Clin Invest Med.* 2001;24(1):44-53.
10. Fang D, Meyer RE. Effect of two Howard Hughes medical institute research training programs for medical students on the likelihood of pursuing research careers. *Acad Med.* 2003;78(12):1271-1280. DOI: 10.1097/00001888-200312000-00017
11. Houlden RL, Raja JB, Collier CP, Clark AF, Waugh JM. Medical students' perceptions of an undergraduate research elective. *Med Teach.* 2004;26(7):659-661. DOI: 10.1080/01421590400019542
12. Jeste DV, Halpain MC, Trinidad GI, Reichstadt JL, Lebowitz BD. UCSD's short-term research training programs for trainees at different levels of career development. *Acad Psychiatry.* 2007;31(2):160-167. DOI: 10.1176/appi.ap.31.2.160

13. Spencer AL, Brosenitsch T, Levine AS, Kanter SL. Back to the basic sciences: an innovative approach to teaching senior medical students how best to integrate basic sciences and clinical medicine. *Acad Med.* 2008;83(7):662-669. DOI: 10.1097/ACM.0b013e318178356b
14. Frishman WH. Student research projects and theses: should they be a requirement for medical school graduation? *Heart Dis.* 2001;3(3):140-144. DOI: 10.1097/00132580-200105000-00002
15. Dyrbye LN, Thomas MR, Natt N, Rohren CH. Prolonged delays for research training in medical school associated with poorer subsequent clinical knowledge. *J Gen Intern Med.* 2007;22(8):1101-1106. DOI: 10.1007/s11606-007-0200-x
16. World Federation For Medical Education (WFME). European Specifications for WFME Global Standards for Quality Improvement in Medical Education. Copenhagen: World Federation for Medical Education; 2007. Available from: <http://www3.sund.ku.dk/>
17. Diez C, Arkenau C, Meyer-Wentrup F. Why German medical students abandon dissertations. *Brief Communication. Educ Health.* 2000;13:97-100.
18. Dewey M. Medizinische Dissertation: Wie unterscheiden sich erfolgreiche von abgebrochenen Forschungsprojekten? *Dtsch Med Wochenschr.* 2002;127:1307-1311.
19. Kock N, Gauer IC, Busch LC, Kirchner H. Betreuung medizinischer Doktoranden im interuniversitären Vergleich – Sollte das Promotionsverfahren geändert werden? *Dtsch Med Wochenschr.* 2000;125:724-728. DOI: 10.1055/s-2007-1024469
20. Diez C, Arkenau C, Meyer-Wentrup F. The German Medical Dissertation – Time do Change? *Acad Med.* 2000;75(8):861-863.
21. Cohen J. A power primer. *Psychol Bull.* 1992;112:155-159. DOI: 10.1037/0033-2909.112.1.155
22. Johnson SB. Recommendations for research success: one investigator's perspective. *J Clin Psychol Med Settings.* 2008;15(1):54-59. DOI: 10.1007/s10880-008-9104-0
23. McGee R, Keller JL. Identifying future scientists: predicting persistence into research training. *CBE Life Sci Educ.* 2007;6(4):316-331. DOI: 10.1187/cbe.07-04-0020
24. Ruble JE, Lom B. Online protocol annotation: a method to enhance undergraduate laboratory research skills. *CBE Life Sci Educ.* 2008;7(3):296-301. DOI: 10.1187/cbe.08-02-0007

Corresponding author:

Dr. Olaf Kuhnigk, MD, MME (Bern)
 Universitätsklinikum Hamburg-Eppendorf, Klinik und
 Poliklinik für Psychiatrie und Psychotherapie,
 Martinistraße 52, D-20246 Hamburg, Deutschland,
 Telefon: +49 (0)40/7410-57675, Fax: +49
 (0)40/7410-54702
 Email: o.kuhnigk@uke.de

Please cite as

Kuhnigk O, Böthern AM, Reimer J, Schäfer I, Biegler A, Jueptner M, Gelderblom M, Harendza S. Benefits and pitfalls of scientific research during undergraduate medical education. *GMS Z Med Ausbild.* 2010;27(5):Doc72.
 DOI: 10.3205/zma000709, URN: urn:nbn:de:0183-zma0007094

This article is freely available from

<http://www.egms.de/en/journals/zma/2010-27/zma000709.shtml>

Received: 2009-12-29

Revised: 2010-06-19

Accepted: 2010-08-03

Published: 2010-11-15

Copyright

©2010 Kuhnigk et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en>). You are free to Share – to copy, distribute and transmit the work, provided the original author and source are credited.