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

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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.

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