Integration of Scientific Competence into Gross Anatomy Teaching Using Poster Presentations: Feasibility and Perception among Medical Students

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Scientific competencies, as defined in the German competency framework, describe the ability to think independently and act scientifically which is a central component of medical education. This report describes integration of scientific competencies into anatomical teaching. Based on findings seen in two consecutive years of dissection courses, students worked on either a case report (n = 70) or an original research study (n = 6) in the format of a scientific poster while learning to use primary literature. Posters were evaluated by juror teams using standardized evaluation criteria. Student perception of the project was assessed by quantitative and qualitative data obtained from the faculty’s course evaluation and an online-survey. Overall, students worked collaboratively and invested extra-time (median 3.0 hours) in poster creation. Primary literature was integrated in 90.8% of the posters. Overall poster quality was satisfactory (46.3 ± 8.5 [mean ± standard deviation] out of 72 points), but several insufficiencies were identified. Students integrated information gained from the donor’s death certificate, post-mortem full-body computed tomography (CT) scan (22.4%), and histopathological workup (31.6%) in their case reports. Students responded positively about learning new scientific skills (median 4.0 on a six-point Likert scale), but free-text answers revealed that some students experienced the project as an extra burden in a demanding gross anatomy course. In summary, it was feasible to introduce students to scientific skills during the dissection course and to increase interest in science in approximately a third of the survey respondents. Further adjustments to ensure the posters’ scientific quality might be necessary for the future. Anat Sci Educ 15: 89–101. © 2020 The Authors. Anatomical Sciences Education published by Wiley Periodicals LLC on behalf of American Association for Anatomy.

Key words: gross anatomy education; medical education; undergraduate education; inquiry-based learning; pathology; poster presentation; scientific working

INTRODUCTION

The teaching of scientific competencies, including literature research, the application of scientific methods, data collection, data presentation, critical data analysis and interpretation, form the base of evidence-based medicine for prospective physicians. Basic knowledge and skills in scientific work are applied in daily clinical practice when solving problems at the patient’s bedside, for example, in assessing and communicating new therapeutic methods. Ultimately, this evidence-based approach to clinical problem-solving results in improved patient care and safety.

Such scientific competence has to be established through academic training in undergraduate education. Students not only need to learn existing knowledge but should also be...
involved in the process of knowledge generation in a “spirit of inquiry” at an early stage of their studies (Healey, 2005). The development of scientific competencies and their application form a foundation for the student’s later clinical activity (Katkin, 2003). Additionally, the integration of research content can be a promising strategy to promote students’ interest in engaging in a doctoral thesis or a career in research or academia. In the long term, this could address shortages of physician-scientists (Solomon et al., 2003; McLean et al., 2013).

Repeatedly, a lack of scientific content has been criticized in German medical schools and the reinforcement of scientific content has been advocated. Medical schools both, in Germany and globally, have acknowledged this concern (Frenk et al., 2010; Lammerding-Koeppe et al., 2018) and have subsequently anchored scientific competencies in their medical curricula. In this context, reference should be made to the Canadian learning objectives catalog CanMEDS (Frank, 2005), the British “Tomorrow’s Doctors” document (GMC, 2009), and the German NKLM competency framework (National Competence-Based Catalog of Learning Objectives for Undergraduate Medical Education), (NKLM, 2015).

However, the implementation of these teaching guidelines frequently presents difficulties. These include inflexible curricula that offer little time or contact opportunities for students to deal with research issues, a lack of role models, and bureaucratic difficulties in implementing research activities for students during their studies (Scarla, 2004; Robinson et al., 2007; Mileder, 2014; Ratte et al., 2018).

Learners recognize the importance of scientific competencies and actively relay competencies they need mentorship in (Epstein et al., 2018; Ratte et al., 2018). Most frequently, they seek advice on topics like critical analysis of scientific publications and scientific writing (Ratte et al., 2018). Similarly, students value the opportunity to gain scientific competencies (e.g., analysis of scientific work, collaborative and independent work, methodological competence, etc.), to explore future occupational fields or to improve their individual career options through research activities during their studies (Houlden et al., 2004; Lopatto, 2004; Murdoch-Eaton et al., 2010; Madan and Teitge, 2013; Imafuku et al., 2018).

Students have described the difficulties they experience when engaging in scientific activity. In addition to the high investment of time required, students were deterred because of insufficient incentives to work in science during their studies, poor supervision or lengthy, repetitive activities (e.g., in the laboratory), which rarely lead to an immediate experience of success (Murdock-Eaton et al., 2010; Chang and Ramnanan, 2015). Such experiences significantly influence their interest and motivation in research. In Germany, a majority of medical students believe that scientific work will not play a major role in their future clinical work as a physician (Ratte et al., 2018). Nonetheless, 85.1% of the students surveyed stated that they were aiming for a doctoral thesis, which is mandatory to gain the title medical doctor (MD), in Germany “Dr. med.” This is confirmed by a ratio of approximately 60% of doctoral graduates (Dr. med.) among German medical students (Deutscher Hochschulverband, 2016). It appears reasonable to assume that medical students gain scientific competence mostly within the limits of their doctoral thesis and that they are motivated primarily by the incentive to acquire an academic title (Dr. med.) (Ratte et al., 2018). However, according to the German NKLM, scientific competencies should be mastered by all students, and not only by doctoral graduates (NKLM, 2015). Ultimately, this means that scientific work has to be embedded in the curriculum and should not be merely an optional eligible “add-on” to the students’ medical training (Knight et al., 2016). The comprehension of the way research is to be defined, recognizing opportunities to come into contact with research during one’s studies, and finally, the proper scientific working skills should be learned before starting a doctoral thesis (Murdock-Eaton et al., 2010; Epstein et al., 2018). Even when students do take the opportunity to gain experience in scientific work during their studies, they still perceive research as an isolated entity and have difficulty relating research issues to current teaching content or patient care (Murdock-Eaton et al., 2010; Imafuku et al., 2018). Therefore, it should be a goal of medical education that students experience clinical and scientific work, as an inseparable unity in medical professions, and to provide sufficient opportunities in pre-clinical and clinical subjects for students to participate in research (McLean et al., 2013).

By the time the Masterplan 2020 (BMG, 2017)—a comprehensive package of measures to restructure medical curricula in Germany—comes into effect, universities will be required to provide and assess scientific competencies in their educational curricula. Globally all medical schools offer a wide spectrum of teaching formats, for example, summer schools, electives or mandatory courses for scientific and scholarly work. In their review, Chang and Ramnanan (2015) summarize the experiences of a total of 20 voluntary or compulsory medical study programs in Brazil, Europe, United States, and Canada. Additionally, the integration of scientific teaching content has been demonstrated for curricula in Asia (Imafuku et al., 2018). Moreover, similar programs have been offered in other health professions, including osteopathy and nursing sciences (Wharrad et al., 1995; Smith-Barbaro and O-Yurvati, 2016). However, there is limited information available on how scientific teaching is integrated into anatomical teaching to ensure that students perceive science as an underlying principle rather than as an isolated entity.

As a time-tested method for teaching anatomical contents, anatomists in many countries still favor the use of dissection (Patel and Moxham, 2006; Korf et al., 2008; Böckers et al., 2010; Estai and Bunt, 2016), because it allows “integrated learning and critical thinking” (Zhang and Fenderson, 2014). However, as curricula changed from a subject-based organization toward integrated/system-based curricula, so did anatomy teaching, with dissection being replaced or supplemented by prosecution or alternative teaching methods (McLachlan and Regan de Bere, 2004; Rizzolo and Stewart, 2006; Winkelmann, 2007; Brooks et al., 2015; McBride and Drake, 2018). A similar trend could be observed in Germany, whereby currently approximately a third of the universities abandon traditional dissection courses and adopted new modular organ-based anatomy courses (Hibbeler, 2014). Both these curricula are a part of a six-year course of study, which after five years leads to a practical year and is completed with a state board examination.

The medical curriculum at Ulm University is organized in a subject-based manner. In total, students receive 344 teaching units (TU = 45 minutes) in anatomical training divided into 108 TU in histology and 236 TU for gross anatomy, including 84 lectures, 38 seminar lessons, and 114 TU in the gross anatomy laboratory. The dissection course for medical and dental students occurs in the second academic year during the winter term. Prior to this course, students attend lectures, seminars, and practical courses on embryology, general anatomy, and histology.

Working in the anatomy laboratory includes hands-on dissection of all bodily regions of a body donor (ventral and dorsal trunk wall/lower and upper limb/situs/head-neck region
and central nervous system [CNS]) within 16 weeks or 25 course days (114 TU). A dissection manual, a catalog of learning objectives, and checklists of required structures are provided to the students via a digital learning platform. Students have the opportunity beyond regular course hours to learn in a self-directed manner using the body donor, prosected specimens and models.

In total, students complete five examinations at approximately three-week intervals in oral and written examination styles. Written examinations are based on multiple-choice questions (n = 30 items per examination), including different levels of Bloom’s taxonomy. Oral examinations are performed in a 1:1 setting (student:teacher) for 10–15 minutes with practical tasks, whereby students have to demonstrate five structures of increasing difficulty on the body donor, on models or in CT images.

Hands-on work is performed in 38 small groups of 10 students, each group working on one body donor. A peer teacher is assigned to each student group and a lecturer supervises two or three student groups. For many years, the semester has ended after a memorial service in appreciation of the gift from the body donors. In addition, the semester is completed by an event that includes a guest lecture, a poster session, and the opportunity for informal and relaxed interaction between teachers and students (“student meets professor”).

At Ulm University, scientific competencies according to the NKLM are represented in a longitudinal interdisciplinary curriculum throughout the entire study phase. In the gross anatomy laboratory, students encountered body donors who exhibit typical age-related changes and pathologies that are characteristic of the local population (Konschake and Brenner, 2014). These findings from the “first patient” in their professional career has regularly inspired students to bring up numerical diseases, which are considerations that differ from clinical practice guidelines (e.g., at least one primary literature source from the PubMed database (U.S. National Library of Medicine, National Institutes of Health, Bethesda, MD) or official clinical practice guidelines as published by the Institute for Medical Knowledge Management of the German Association of the Scientific Medical Societies (AWMF-IMWi, Marburg, Germany)).

Learning goal 2. To present findings from the dissection as a case report or an original research study to facilitate interpreting the donor diagnostically and to evaluate them in the context of the existing literature.

Learning goal 3. To communicate the results of the dissection in a systematic way using Case Reporting Guidelines (Gagnier et al., 2013) and Guidelines for Poster Production (Erren and Bourne, 2007; Gundogan et al., 2016) to a professional audience by means of a scientific poster.

Students were informed about the project within the course-accompanying lecture and via the institute’s website. Lectures explained the project course and the importance of posters in scientific communication as well as the difference between primary and secondary literature. In addition, students were provided with a template for the principal poster design, an example of a finished poster, a short video tutorial on literature retrieval in PubMed, and tips on poster design (font size, layout, labeling, structuring, references, etc.) as well as on the above-mentioned literature and links to [PubMed and AWMF guidelines (German Association of the Scientific Medical Societies, Marburg, Germany)].

Each student group (n = 38 per year) was obligated to participate in the project by creating a poster. The engagement of individual group members and the assignment of specific tasks was the team’s responsibility. The selection of poster topics was performed in a self-directed manner within each student group. A mandatory pre-submission by each student group (stating the poster topic) occurred at the end of the 12th course week (Fig. 1), and the final submission of poster files (ppt and pdf format) was due in course week 13. Subsequently, the posters were briefly reviewed, but not evaluated, following the criteria of the evaluation template (Supplemental Material File Appendix A). In the case of failure to follow the general criteria of poster creation, the group was asked to submit a revised poster version. Thereafter, the posters were printed in A0 format (84.1 by 118.9 cm).

During the duration of the dissection course, the student groups had the option to document the dissection process, anatomical variabilities or pathological abnormalities by photographic recording using the tablets available to each student group. The photo recording was always conducted in full compliance with the donor’s confidentiality. The body donors were pseudo-anonymized by a sequential number on admission to the institute and photographs were taken only of isolated body regions that did not allow the identification of individual

MATERIALS AND METHODS

Research Question 1. Teaching Scientific Competencies through Poster Presentation—Project Design

In the winter term 2018/2019, a team-based teaching format of creating and presenting a scientific poster was implemented. The posters were judged by a jury (six poster teams, each consisting of two jurors who evaluated 6–7 of the 38 posters). For the best poster, each participant of the winning group was awarded a book voucher. However, the evaluation of the posters was not credited to the students’ overall performance in course examinations. The aim of the project was to enable students to experience scientific work according to their educational level in a positive and self-motivating learning environment. Therefore, greater emphasis was placed on a limited number of easy-to-access competencies rather than on mastering complex competencies perfectly. On the basis of the learning objectives for scientific work stated in the NKLM, the following learning objectives associated with the dissection process were defined:

Learning goal 1. To evaluate and describe results obtained in the dissection process using the best available evidence [e.g., at least one primary literature source from the PubMed database (U.S. National Library of Medicine, National Institutes of Health, Bethesda, MD) or official clinical practice guidelines as published by the Institute for Medical Knowledge Management of the German Association of the Scientific Medical Societies (AWMF-IMWi, Marburg, Germany)].

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donors. Following the recommendations of Jacobson et al. (2009), macroscopic findings could be further analyzed by the use of imaging techniques to obtain more detailed information about the clinical case of the respective body donor. Over the duration of the course, students had access to post-mortem full-body computed tomography (CT) scans (layer thickness 1 mm; prepared using a Siemens SOMATOM Definition AS 128 Slice CT scanner [Siemens AG, Munich, Germany] in the Clinic for Diagnostic and Interventional Radiology at the University Hospital, Ulm). Images could be viewed using an open-source DICOM viewer for Macintosh tablets. As already performed in other anatomical institutes, a board-certified histopathologist was invited to attend the course during the dissection of the thoracic and abdominal cavities (course week 9, see Fig. 1) (Wood et al., 2010; Meredith et al., 2019). Every student group had the choice to register for organ demonstration with the pathologist (“pathology ward round”) to discuss any unusual or unexplained macroscopic findings. In cases where a definitive diagnosis could not be made based on macroscopy alone, formalin-fixed (4% buffered formaldehyde) tissue samples were submitted for histopathological workup using routine hematoxylin and eosin (H&E) preparation. The results from these analyses, including immunohistochemical and molecular data, were presented to the students by the pathologist at a second meeting. Finally, information from the death certificate and, as previously described by Wood et al. (2015), a brief written report on the donor’s medical history from the donor’s physician (not available for all body donors) was communicated to the students. Photographic documentation, histology images, and CT cross-sectional images were available for poster production.

Each year (2019/2020), 38 posters were presented. While each poster (n = 6) evaluated assigned posters (n = 6–7), all event participants had the opportunity to view and discuss the posters at the same time (exactly as it is at scientific meetings). Each poster committee was formed by a medical student of an advanced study year and a non-anatomical colleague (e.g., from departments of biochemistry, anesthesiology, psychosomatics, psychiatry, dentistry). Each juror reviewed the assigned posters independently. Prior to the five-minute poster presentation and discussion, members of the poster committees were provided with the digital files of assigned posters and an evaluation guideline (Supplemental Material File Appendix A) to aid in preparation. There was no prior training of the poster judges. Poster evaluation was performed according to pre-defined criteria listed in a standardized evaluation guideline (Supplemental Material File Appendix A). Thereby, poster layout (8 points), content (20 points), and presentation (8 points) were rated. The poster with the highest score was awarded the above-mentioned poster prize. The best three posters were displayed in the dissecting hall and could subsequently be studied by following student classes. Following the poster presentation, each student group was allowed to take possession of their poster.

As an example of a case report (Title: Alarm in the intestine) the authors summarize below the content of the winning poster from the 2018/2019 course in English (Supplemental Material File Appendix B in the German language). As an example of a poster created by the students in the format of an original research study, the winning poster from the 2019/2020 course can be found as Supplemental Material File Appendix C (in the German language).

Example of a case report. The students estimated the age of the patient/body donor to be 78 years, and they described the patient’s potential medical history and the diagnostic and therapeutic procedures that the patient may have undergone. From the donor’s death certificate, the students retrieved the cause of death, a (paralytic) ileus, most likely caused by mechanical obstruction due to nodal metastasis to the mesenteric lymph nodes. However, the primary tumor was unknown to the doctor who issued the death certificate.

Subsequently, the students explained the methodical procedure of donor dissection: the anterior wall of the trunk was removed along the anterior axillary line and the abdominal cavity was opened. It was attempted to reconstruct the vessel arcades adjacent to the intestines and their supplying branches of the superior mesenteric artery up to its origin at the aorta. A few centimeters distal to the branching of the superior mesenteric artery from the aorta, a solid mass (diameter approximately 5 cm) was encountered (Fig. 2A,B). To investigate the entity of the tumor, the students localized the swelling in the post-mortem full-body CT-scan. The tumor could be identified because it was interspersed with irregularly distributed calcifications (Fig. 2C). Tissue samples of the mesenteric mass were submitted for histopathological examination. Specimen stained with H&E showed a proliferation of polygonal, monomorphic cells with coarse, speckled chromatin, arranged in a characteristic Zellballen (small nests) pattern, and separated by fibrous septa (Fig. 3B). Taken together, the diagnosis was consistent with nodal metastasis from a moderately differentiated neuroendocrine tumor (NET-G2), most likely originating from the gastrointestinal tract. Not knowing the localization of the primary tumor, the student group conducted a self-guided search for a primary tumor from which the detected metastasis had originated. The superior mesenteric vessels supply parts of the pancreas, the small intestine, and parts of the large intestine. Therefore, it was most likely that tumor cells should originate from these organs. The pancreas was examined during this search, but no tumor lesions

Figure 1.

Project timeline. The figure summarizes the chronological order of the teaching project in relation to the dissection process. Each week is symbolized by color arrow. Examinations are indicated with white circles, while filled circles indicate visits of the pathologist. Data collection was possible throughout the course, but students had to submit their poster theme at timepoint “A,” their final poster at timepoint “B” and the poster presentation took place at timepoint “C.”
Figure 2.

Tumor found in the root of the mesentery and postmortem CT image. A, the intact tumor in the area of the proximal root of the mesentery (black arrow). The radial branches of the superior mesenteric artery are aligned upwards to the left. The vessel arcades and the intestinal loops were removed. Origins of the vessels are marked with a white asterisk. B, the tumor was sliced in half (black asterisk) revealing a coarse, dark capsule (black arrow). The largest diameter of the tumor was approximately 5 cm. C, a computed tomography image of the metastasis in the root of mesentery (white oval) in the horizontal section (lumbar level L3-L4). The tumor contained several strongly radio-opaque calcifications. Likewise, the aorta shows a buckle-shaped calcification.

were found. Thereafter, the entire small intestine was incised longitudinally and the mucosal surface was examined. A flat tumor approximately coin-sized was found at the jejunoileal junction (Fig. 3A). In summary, by means of an explorative/scientific approach, students were able to draw up a postmortem diagnosis for their “first patient” (NET-G2 of the small intestine) with nodal metastasis to the mesenteric lymph nodes (pT2pN2, Stage III).

The ethics committee of the University Ulm deemed this study exempt from formal review (written reply from the ethics committee dated from 27 November 2019). The data presented in this report were collected from a body donor (No. 3490) who bequeathed their body to the anatomy institute. This donor provided written consent for their body to be utilized for the purpose of research and educational training of medical students.

Data on poster quality in the present report are presented primarily based on a follow-up assessment of all posters that were performed by the first and last authors using the evaluation guideline (Supplemental Material File Appendix A). These data are substantiated by the quantitative evaluation of the poster judges presented as mean (MN) ± standard deviation (±SD) plus median values (MD). These poster judges, however, had only rated a certain proportion of the posters. The interrater reliability between the two members of a poster committee was calculated using the Cohen’s K online calculator (Hemmerich, 2020) based on the specifications by Altman (1990).

To understand the impact of the poster project, free text entries of the general evaluation of the dissection course (2019/2020) performed by the faculty were searched for the terms “poster/placard.”

The qualitative analysis of all obtained comments was performed using grounded theory (Glaser and Strauss, 1967). Therefore, text passages were segmented, coded, and categorized. Categories were reviewed by a second person. Inconsistencies were identified and in case of disagreement, discussed until a shared consensus could be found. Finally, the number of codes for each category were quantified.

All students of the latter year (n = 373) were invited to participate in an online-survey using licensed access to Questback software, version EFS Fall 2019, (Questback GmbH, Cologne, Germany). A paper-based version of the questionnaire was translated into English and provided as Supplemental Material File Appendix D.

The study cohort was characterized by a mean age of 22 years (±3.2 years) and 64% female sex. Most students (88.5%) studied medicine, 11.5% dentistry and 4% of the students had completed another study course before starting medical training. Students participating in this survey indicated their consent on the questionnaire. The survey’s questionnaire (n = 18 items) was developed by undergraduate medical students (co-authors: D.S., A.R., M.S., L.S.) and reviewed by senior anatomy lecturers. A paper-based version of the questionnaire was tested during a pilot study the year before. Items were related to general information about the student, as well as the experienced workload, problems, and learning effects through the project and the project’s overall evaluation. Items could be answered quantitatively using a six-point Likert scale (1 = not true at all; 6 = absolutely correct), multiple choice answers or nominal (yes/no) options. The survey’s internal consistency was calculated as 0.67 (Cronbach’s α). The questionnaire data were imported into SPSS statistics software, version 22, (IBM Corp., Armonk, NY) and subsequently analyzed descriptively. Collected data are reported in mean (MN), ± standard deviation (± SD) and median (MD) values.

RESULTS

Results of Teaching Scientific Competencies through Poster Presentation

Most of the 76 posters (91 %) (2019 and 2020) described topics resulting from (pathological) conditions found in their body donor followed by the development of a case report. Only six student groups adopted the concept of asking scientific questions in order to present the collected data in the format of an original research study. Formulating research questions and hypotheses represent an important scientific competence, but was not an explicit learning objective in this project. In terms of chosen poster themes, the presented case reports described a variety of pathologies in almost all organ systems which are listed in Tables 1 and 2. Contributions on the CNS were frequently underrepresented, because the posters had to be submitted prior to the section which dealt with the CNS.
Overall, the evaluation results awarded by all six poster committees (top possible score: 72) achieved an MN of 46.3 ± 8.5 points (Min 26; Max 61 points). The poster committees displayed diverging inter-rater reliabilities when comparing the evaluation data of the student jury member and the pre-/clinical colleague teacher. Cohen’s K achieved partly moderate values (k = 0.404; z = 5.95; P < 0.001), but in part only inadequate values (k = 0.198; z = 3.05; P = 0.002). An independent evaluation of the posters by the above-mentioned authors
focusing on the previously defined learning objectives resulted in the following findings:

**Learning Goal 1. Students should learn to evaluate and describe the results of the dissection using the best available evidence (e.g., at least one primary literature source from the PubMed database or AWMF guidelines).**

All posters in the format of a case report properly described the pathological findings of their body donors. Of the 76 posters, 69 (90.8%) included at least one source from the primary literature, mostly one to five publications. However, some groups had a tendency to search for their references through common internet search platforms (e.g., Google; Google Ireland Limited, Dublin, Ireland) or on common student learning platforms (e.g., AMBOSS; AMBOSS GmbH, Berlin, Germany) rather than in PubMed. Furthermore, deficiencies also became apparent with respect to a proper citation style. Some posters lacked in-text citation, information about the journal or the title of the cited reference, or even all of these details as National Center for Biotechnology Information (NCBI) links or PubMed identification numbers alone were listed. Authors were sometimes not cited in the correct form: for example, author name “et al.” or a random number of authors followed by “et al.” Sixteen student groups concentrated on references published in their native (German) language and in one case it may be assumed that only the abstract of the cited reference was read. Because a full-text version was not available in PubMed and the original article had been written in Cyrillic.

**Learning Goal 2. Students should learn to present certain findings from the dissection in the format of either a case report or an original research study in a systematic and structured way, in particular using textual methods, to interpret them diagnostically and to evaluate them in the context of existing literature.**

All but one student group had used the poster template provided. However, some of the poster templates were modified in minor aspects, for example, the institute’s or university’s logo was removed, author specifications were moved to the end of the poster (n = 3), or subdivisions were simply omitted. In total 63 (85.5%) student groups made use of the facilities provided for photo documentation, 17 groups (22.4%) integrated images of the full-body CT-scan of their body donor into their poster, and 24 groups (31.6%) integrated microphotographs from the histopathological assessment. Of those with microphotographs, 20 of the poster authors did not list the histopathologist either as a co-author or within the acknowledgments. Occasionally, the histopathologist was mentioned as an image source within the posters.

Overall, the posters of more than half of the student groups complied with the formal requirements (see Supplemental Material File Appendix A) regarding poster production. On average the posters’ layout was rated at MN ± SD of 5.5 ± 1.6 points (MD 6.0; maximum 8 points) and the posters’ content 13.2 ± 3.1 points (MD 13.0; maximum 20 points) as evaluated by the poster committees. Three groups labeled their poster as an original research study, instead of the correct designation of case report. In many cases, the image captions, legends or scaling or details about image origins and their authorship were lacking. Some posters were arranged in an unstructured and text-heavy fashion. In contrast, the poster themes were frequently very well elaborated, but often the students were unable to correlate the information gathered on the disease in the literature with their own findings observed on the body donor. The poster jury awarded an 4.4 ± 1.1 points (MD 4.0; maximum 8 points) for the poster presentation.

**Table 2.**

| Posters (n = 6)                                                                 |                  |
|--------------------------------------------------------------------------------|------------------|
| Learning Goal 3. Students should learn to communicate the results of the dissection in a systematic way to a professional audience by means of a scientific poster. |

In principle, this learning objective was demonstrated only by those students who presented the poster in person while representing their group. However, it can be assumed that the remaining group participants experienced a learning gain during the rehearsal of the poster presentation within the group when acting as observers and/or feedback providers.

**Integration of histopathological findings.** A total of 40 tissue samples were taken from 31 body donors. The quality of the H&E staining from formalin-fixed, paraffin-embedded tissue samples—which was performed a mean of 1.5 years after the death of the body donor—was satisfactory, which is in agreement with results from a previous research study (Rae et al., 2018). Immunohistochemistry or molecular analyses could not be successfully performed in all tissue samples, which was most likely due to the long period of formaldehyde-based preservation of the body donors.

**Research Question 3. Experiences and Perceptions of the Students on the Teaching Project**

**Quantitative data.** Of all 373 participants of the dissection course (in 2019/2020) who were invited to participate in the online survey, 162 (62.3% female/37.7% male) answered the questionnaire (response rate 43.2%). A quantitative analysis of the survey revealed that 46.9% of the students stated that they had previously used PubMed for literature research. Another 37.7% had known of PubMed. Students indicated that they had invested approximately 2–4 hours (MD 3.0) for poster production. A majority of the students (74.1%) perceived this time investment as a burden in addition to the already existing learning load (MD 4.0; MN 3.71 ± 1.8 on a six-point Likert scale). Participants in the survey were indecisive whether they felt sufficiently informed on poster creation (MD 3.0; MN 3.28 ± 1.4) and favored the use of the provided poster template. However, about a fifth of the respondents (19.8%)...
indicated that they did not use any of the provided information for poster production. Data from those students who had completed the survey but had not been directly involved in the poster project were excluded. The remaining students most frequently indicated the choice of poster themes (24%), literature research (38%), and condensation of content (48.1%) were particularly difficult. Students highlighted that they had learned competencies not only in the field of the poster’s clinical (31.8%) and pathological content (24%), but also in the field of teamwork (24%) and literature search (21.7%). In contrast, 24% of the respondents indicated that they did not experience gain in any of the listed competencies. Students were unsure whether or not the project was an useful addition to the dissection course (MD 4.0; MN 3.47 ± 1.3), but were positive about the experience of learning new scientific skills (MD 4.0; MN 3.55 ± 1.2). Finally, after project participation, 31% of the students agreed to the statement that their interest in science was increased and 46.5% of the students wished to work on scientific projects more frequently during their studies.

Qualitative data. These data were gained from open-ended questions in the faculty’s evaluation survey, in which all participants of the dissection course were asked to participate. In total, the students returned 26 written responses (4.6%) to the above-outlined project. Qualitative analysis revealed 71 text segments, to which 73 codes were assigned. The majority of the codes indicated a negative perception (n = 47) (Table 3).

Positive text segments (n = 17) stated that anatomists and pathologists were a great source of support (n = 7) and that posters revealed that there was significant anatomical and pathological variability (n = 1). The learning objective of using at least one primary literature source for poster production was perceived by some as an additional workload, a waste of time or basically meaningless (n = 10). Respondents also complained that full-text versions of possibly relevant publications were not available free of charge. One student noted that the poster evaluation criteria lacked transparency, that there was no immediate feedback on the poster, and that the posters were not scientific. However, students also offered proposals for improvement (n = 3), including more direct information through their learning platform, a larger event location, unrestricted access to full-text primary literature, and alternatives like the cessation of the poster project or to offer it as a voluntary course.

In summary, survey respondents indicated that they were willing to invest extra-time in poster production. Students enjoyed the teamwork and elaborating upon clinical topics related to their body donor. Data showed that nearly a third of the respondents stated that participating in the project had increased their interest in science. However, negative open-text answers given by a small number of students (26 out of 570 students participating in the faculty’s evaluation survey) indicated that at this stage of their education some students lack perspective on the meaning of scientific work. Consequently, some students experienced the poster project as an additional, perhaps unnecessary workload. In accordance with the follow-up assessment of the posters performed by the authors, the open-text responses affirmed that the poster quality could be further improved, for example, by clearer communication of assessment criteria and structured feedback.

DISCUSSION

German competency framework considers learning fundamental science during medical education to be essential in medical education (NKLM, 2015). The aim of this report was to demonstrate how scientific work can be integrated into gross anatomy curricula at an early stage of medical education via scientific posters.

Research Question 1. Description of the Performed Teaching Project

According to this research question, the manuscript and submitted appendices provide a detailed description of the project. The poster project has proven to be a suitable method for documenting findings detected during the dissection process. It was readily implemented because it did not require any significant additional personnel or resources (apart from expenses for poster production with the institute bearing the cost). A poster presentation focuses on the mediation of scientific competencies. However, there might be other methods to document the dissection process. Alternatively, an e-portfolio system, as introduced by Harris et al. (2015), could be a suitable method to create a cadaver autopsy report. Both methods motivate students to interpret anatomical and pathological findings, to correlate these with the donor’s cause of death, and to reflect on their potential impact on the donor’s previous life.

Posters dealt with numerous pathologies that have been similarly documented in other dissection courses (Wood et al., 2010; Wood et al., 2015; Plummer et al., 2018). However, depending on the geographical location of a university or anatomical institute, the prevalence of pathological entities can vary considerably (Geldenhuys et al., 2016). In agreement with the above-mentioned research groups, the dissection of a cadaver was considered a valuable tool to integrate pathology into medical training and to foster observational skills (Burton, 2005).

The presented case report clearly illustrates that the dissection course does not only convey factual knowledge obtained from anatomical textbooks, but additionally it allows students to investigate clinical and scientific questions in a self-directed manner using additional resources like dissection, post-mortem CT scans, and pathological expertise. Of note, the poster project motivated students to pursue the dissection of the body donor beyond the common anatomical target structures to finally establish a post-mortem diagnosis, which, according to Schenk (2019), only succeeds in 25%–30% of autopsies of patients with carcinoma of unknown primary origin. Students identified the primary carcinoma and generated new data through their investigations. Similar observations were made by Alyafi et al. (2012), who reported on a case of abdominal aortic aneurysm in the dissection course that highlighted the benefits of student-directed dissection in learning clinical anatomy.

Research Question 2. Evaluation of Poster Quality and the Accomplishment of the Intended Learning Goals

Follow-up poster assessment showed that the learning goals of this question, including the workup of primary literature, were achieved by more than 90% of the student groups. This excellent success rate may be explained by the fact that a substantial proportion of the students had previously been introduced to PubMed or had earlier used the service (possibly, during a
curricular teaching unit in their previous semester). Similar to the here presented results, Rauschenbach et al. (2018), reported that 65% of the investigated students described a prior experience with scientific work. Nevertheless, the present survey results showed that nearly a fifth of the students did not participate in the group exercise. This fact may be related because the poster project was not subject to official examination and students in each group were able to divide tasks among group members.

Furthermore, data analysis does not allow any conclusions on factual competencies gained by individual students. In contrast, individual competence growth in students of allied health sciences studying human anatomy could be demonstrated in areas like communicating research answers, correctly citing academic literature or acquiring resources. However, this study was attended by only 24 students and represented self-assessment data (Bentley et al., 2015).

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**Table 3.**
Themes, Number of Codes, and Illustrating Sample Quotes Identified from Student’s Free Text Responses in 2018 and 2019 Academic Year

| Themea,b | Sample Quotes |
|---|---|
| **Positive perception (n = 17)** | |
| General positive perception (n = 2) | “[…] I also found the poster preparation very enjoyable.” |
| Support by pathological expert (n = 7) | “It was very cool and accommodating that the pathologist dedicated himself to the analysis of the tissue samples’ in a really expert way’ - a great benefit also for the poster. |
| Support by anatomy lecturer (n = 5) | “[…] the pathologist (who was super helpful)” |
| Appreciation of the body donor (n = 1) | “I think it is interesting to see what the other tables have found in terms of norm variants and pathologies.” |
| Relevance of scientific working (n = 2) | “[…] In my opinion, scientifically in medical education is important.” |
| **Negative perception (n = 47)** | |
| General negative perception (n = 2) | “In my opinion, the poster design and presentation was not ideal, […]” |
| No extra benefit (n = 10) | “The poster work is a bit of a waste, […]” |
| Organization (n = 10) | “Location is not particularly suitable.” |
| Time and learning stress (n = 9) | “[…] because at this stage nobody has the time and nerves, […]” |
| Primary literature (n = 6) | “[…] especially the use of primary sources is inappropriate (disproportionate), […]” |
| Poster evaluation (n = 5) | “Evaluation criteria are not transparent. No feedback. […] For example, serious shortcomings such as the failure to name the persons involved (e.g. the pathologist) […] were overlooked this year. That is grossly negligent and absolutely unprofessional!” |
| Poster quality (n = 5) | “[…] therefore, the poster is created only half-heartedly and with minimum effort, which is a great pity.” |
| Proposals for improvement (n = 5) | “Perhaps it would be a good idea to offer a separate course in order to engage more intensively with science while having more time for it.” |
| Not applicable (n = 4) | “I would have liked it if important information […] would be communicated on Moodle not only on the institute’s homepage.” |

aNumber of codes related to this theme; bAnswers of 26 students were segmented (n = 71), coded (n = 73) and categorized (n = 13).
Additionally, students’ comments illustrate that some of them did not view working with primary literature as useful and that they were unaware that it is common practice for researchers to obtain primary literature through interlibrary loan or access to other services. These statements reflect the expectable state of knowledge and attitudes among pre-clinical medical students and should thus be taken into consideration when conducting scientific projects. Additionally, it should be kept in mind that the students’ opinions presented in the present report are based on self-evaluation, which could markedly differ from objective criteria. For example, students did not report any difficulties in image processing, nevertheless, the authors frequently identified deficiencies in this aspect, including information lacking on scaling/magnification or absent image inscriptions or legends. In the future, well-controlled and randomized studies will be necessary to objectify learning gain based on knowledge retrieval, for example, in written examinations.

Research Question 3. Data on the Students’ Perception of the Project Based on Quantitative and Qualitative Survey Data

Approximately 50% of the survey respondents appreciated the project as a meaningful contribution to the dissection course and to learn scientific competencies. Overall, interest in science was encouraged in one-third of the respondents. An even more positive attitude toward research and scientific methodology was previously described for fifth-year German medical students in traditional or problem-based curricula (Pruskil et al., 2009). Rauschenbach et al. (2018) reported that 72% of students felt that their scientific writing skills had improved as a result of engaging with a scientific project.

Students and anatomists in the present study perceived the contribution of the pathologist as extraordinarily positive in assisting students to associate clinical conditions with gross and microscopic anatomy. Organ demonstrations conducted by pathologists promoted contact with pathology and offered an important opportunity to highlight both, anatomical variations and a broad spectrum of pathological conditions. This experience agrees with the results of other working groups, who showed that interaction with a pathologist helped students to better understand the clinical relevance of anatomy and strengthen their scientific mindsets (Burton, 2005; Wood et al., 2015; Rae et al., 2017; Plummer et al., 2018; Meredith et al., 2019). According to Rae et al. (2017), more of such interactions were requested by 74% of students. In the future, beyond pathology, other clinical disciplines could make use of body donors within an interdisciplinary teaching structure as it has already been realized in the field of dermatology (Baker et al., 2014).

In accordance to a survey undertaken previously by the authors, studying anatomy in a case-based manner via donor clinical information helped promote students’ appreciation of the clinical relevance of anatomy and an empathic perception of the donor (Bohl et al., 2011b; Hasselblatt et al., 2018). The concept of the body donor as a once-living being with an individual (medical) history counters the impression of the body donor as purely learning objects. This observation has been supported repeatedly in the past (Ferguson et al., 2008; Bohl et al., 2011a; Talarico, 2013). However, students in the present study did not reflect in-depth on the potential merits which writing a case report might have on their perception of the body donor as their “first patient.”

Lecturers’ and students’ views on potential benefits arising from the integration of scientific work into their medical training differ (Imafuku et al., 2018). Lecturers agreed that collaborative work on a project requires competencies that are essential for later scientific activities in research (Huggett et al., 2011). Therefore, poster production required students to decide how to manage a complex project within their teams. In contrast, students did not reflect in-depth on the eventual benefits like group working skills in their evaluations. Instead, some students provided negative feedback related to the additional workload required for the project in an already learning-intensive and examination-heavy semester. Probably, this was because they could not discern any immediate benefit of the project in relation to their forthcoming examinations.

This negative attitude held by some students advocates for more support of scientific competency development. For this very reason, it appears important from a lecturer’s perspective that universities offer opportunities (like the one presented in the current study) throughout medical training programs so that students may participate in more scientific projects and have greater interaction with researchers and representatives of the faculty.

Vice versa, interacting with students in a scientific context provides teachers and researchers in anatomy (and pathology) the opportunity to recruit junior staff, doctoral students and increase their long-term publication output. Corresponding long-term effects were demonstrated for a scholarly research program at Duke and Stanford Universities (Laskowitz et al., 2010). As recommended by McLean et al. (2013), one student group in the present project presented their poster (Poster title: “Stress measured by heart-rate variability being confronted with a cadaver”) at an international meeting (Ferger et al., 2019). Following the suggestions made by Straus et al. (2006) to engage students early in their training with all aspects of academic medicine, students were also involved as co-authors in producing the present manuscript.

Research Question 4. Identification of Opportunities and Difficulties of the Project

It was demonstrated that teaching students how to work scientifically is feasible within the anatomical curriculum. Students’ responses indicate that they were willing to invest extra time, work collaboratively, and learn how to design a poster. Furthermore, they reported, that they learned relevant clinical information from death certificates, post-mortem full-body CT scans, and histopathological workup and integrated these in their poster production. However, it became obvious that while many students had already used PubMed, few students were truly proficient with its use.

Even though the final poster quality was satisfactory, reviews of the posters revealed deficiencies that would not meet standards within an actual scientific context. Therefore, future classes will need more support on tasks like content condensation, citing primary literature or image processing to ensure that an adequate scientific level is achieved.

In addition, students will require further instruction on how to relate information obtained from primary literature with findings from their body donor/patient. To compensate for these weaknesses, researchers need to act as role models (Chopin, 2002; Murdoch-Eaton et al., 2010). Therefore, researchers or any anatomical teaching staff should support...
their student groups in the process of poster development, for example, by providing structured feedback based on the poster evaluation guidelines (Supplemental Material File Appendix A) available to teachers and students in advance of the poster session.

Stress attributed to learning and time pressure were the most common complaints reported by students and these are known to be a serious problem in medical education (Leblanc, 2009). Considering the high learning load during the dissection course, evaluation scores on the presented posters had explicitly not been included in summative examinations. Furthermore, the authors strongly believe, that the motivation for scientific work should primarily be endogenous and not exogenously driven (e.g., by examinations). However, there are examples of successful integration of scientific work projects into curricular examination strategies (Bentley et al., 2015). Tying the project to course examinations could have the positive effect of ensuring the involvement of all students in the project of poster creation and the achievement of the scientific learning objectives.

Limitations of the Study

Quantitative data on the students’ opinions were based on the results of an online-survey with only a moderate response rate. Nevertheless, internet-based surveys have been previously described to achieve lower response-rates than paper-based surveys and the response rate of the present study is above the mean of 33% (Nulty, 2008). It should also be noted that the quality of the factual poster presentations could not be assessed by the authors retrospectively. Jurors’ interrater reliability was only computable between jurors of a single committee because all six committees had worked in parallel, with each committee evaluating different posters simultaneously. Otherwise, poster presentation and the determination of the winning poster would have taken too long. Interrater reliability between jurors of a single committee was low to moderate. However, this is not unexpected given the heterogeneity of the jurors’ scientific expertise (student vs. university employee), a combination that was chosen deliberately to ensure that both groups (students/teachers) were equally represented within the jury. Finally, the presented data were obtained at a single university location and the survey data are based primarily on students’ self-assessment. Future studies should determine whether the project correlates with an increase in scientific competence among students. While long-term effects, for example, on academic career choices, publication output or the number of doctoral graduates (Dr. med.), might not be expected from a single project, it could still deliver valuable data in addition to the already available facts (Fang and Meyer, 2003; Solomon et al., 2003; Abu-Zaied and Alkattan, 2013). As the method of poster production could also be applied to other pre-clinical or clinical-theoretical subjects, including microbiology (Rauschenbach et al., 2018), it might be conceivable that such long-term effects will be measurable once scholarly research activities have been integrated into the teaching concepts of all undergraduate disciplines.

CONCLUSIONS

This is the first article to describe a process whereby the creation of scientific posters was utilized as a means to impart scientific competencies to students in the gross anatomy course. As an incremental contribution, it demonstrates that teaching students how to work scientifically is feasible within the anatomical curriculum. Students were willing to invest extra time, work collaboratively, and learn how to design a poster. The final poster quality was satisfactory, but students had difficulties with certain aspects, including literature research, content condensation, citing primary literature and image processing. Students learned relevant clinical information from death certificates, post-mortem full-body CT scans, and histopathological workup, and integrated these in their poster.

In summary, students’ interest in science was increased to approximately a third of the project participants. However, the students’ opinions of the project were heterogeneous. In particular, the concurrent high workload associated with examinations was viewed critically. On the basis of this project report, which includes project design, criteria for poster evaluation, and first experiences with the project, anatomical colleagues have the opportunity to realize comparable projects in their institutes. Future studies should examine whether the project will actually lead to a measurable increase in scientific competence among students.

NOTE ON CONTRIBUTIONS

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