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It's All in the Mix: A New Interprofessional, Blended-Learning Masters' Program for Biomedical Data Science Addressing Physicians and Students from Life Sciences – Didactic Concept and First Experiences

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Abstract. Progress in methods for biomedical research, such as multi-omics analyses and in data-driven healthcare, such as new procedures in diagnostic imaging lead, along with the rising availability of additional data sources, to a growing demand for experts in biomedical data analysis. Addressing this need in academic education and the challenge of interdisciplinary teamwork in the biomedical domain, the authors have designed and implemented a new Master's program for biomedical data science that accepts students with different educational backgrounds, medical doctors, veterinarians and students with a Bachelor's degree in life sciences, and incorporates blended learning. This paper aims to present the didactic concept of the program, report on feedback from the students and first evaluation results, and discuss the benefits and drawbacks of this approach. Our results show that the program is well-accepted by the students, who stress the benefits of working in interprofessional teams, the option for part-time study along with their jobs with flexible learning opportunities, and of good and intensive interaction offers with their peers and teachers. Readjustments are necessary to improve tutoring support and alignment of content among distinct modules and to decrease workload peaks. While our evaluation results are still preliminary, we are convinced that our approach of mostly online offers, yet with a strong focus on teamwork, practical exercises guided by experts and communication skills, may serve to educate students to be well-prepared for their future tasks and operations in biomedical data science, in research, clinical care and industry.

Keywords. education, didactics, medicine, infection medicine

1. Introduction

With the advancement of digitally supported processes, both in health care and biomedical research, the amount of available data rises continuously. Sources include

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the multitude of omics data, imaging data, data from novel diagnostic tests, from clinical trials, environmental data, and many more. These data are collected led by the assumptions that — with more data available — a more holistic image of patients, pathomechanisms, intracellular pathways, and healthcare provision, in general, can be created and that relevant information can be extracted from the data, once integrated. Data-driven application systems, particularly for (clinical) decision support [1], are becoming increasingly relevant in clinical practice, enhancing the demand for experts in this field.

(Bio-) Medical Informatics "is the interdisciplinary field that studies and pursues the effective uses of biomedical data, information and knowledge for scientific inquiry, problem-solving, and decision making, driven by efforts to improve human health" ([2], p. 21) and as such is inherently interdisciplinary. This also applies to the subfield of biomedical data analytics and biomedical data science, respectively. Without sound knowledge in the biomedical domain, data scientists will experience difficulties, both in choosing the appropriate analytics methods and in interpreting the outcome. An example is to interpret the findings from multi-omics analyses in infection research. A good understanding of pathomechanisms and already known pathways is as important for making sense of the analysis results as is clinical domain knowledge for the question of whether the results can be made applicable in clinical care, e.g., in the form of a decision support application system. Thus, interprofessional collaboration is crucial, yet often hampered by an absence or lack of physicians who also are proficient in data science methods.

To overcome the massive lack of experts in the field of biomedical data science, in particular in the expanding field of infection research, and at the same time also meet the demand for physicians that also have a profound knowledge in data science and have skills in interprofessional collaboration [3], the authors have designed, achieved accreditation for and started in 2021 a new Master's program for biomedical data science at Hannover Medical School in Germany.

The aims of this paper are to:

- report on a new approach for a Master's program in biomedical data science with a strong focus on the didactic concept for interprofessional and blended learning,
- present preliminary feedback and evaluation results from the first student cohort in the program,
- discuss key benefits as well as necessary improvements in the novel concept.

2. Methods

The authors give a short summary of the Master's curriculum along with a description of the didactic concept. Results from a first, preliminary feedback evaluation of the first students are provided and discussed against the background of potential improvements and obvious benefits. We summarize the perceived success factors of the concept concerning the challenge of teaching students with significantly heterogeneous backgrounds and competencies.

3. Results

3.1. Assumptions, target group and basic concept

As stated above, when designing the Master's program, we acted on several assumptions, which strongly influenced our decisions. To address the challenge of interprofessionalism already *during and as a key aim of* the program and to meet the rising demands of data scientists in the field of infection research, we decided to admit students who are either physicians or veterinarians who have already completed their degree and students of biomedicine or life sciences with a Bachelor's degree, e.g. in Biology, Biochemistry or Molecular Life Sciences. To further address the challenge of including physicians who already work in their jobs, we decided to create a curriculum and a didactic concept that allows this group to study part-time.

To implement this program, members of the German Cluster of Excellence RESIST (Resolving Infection Susceptibility, https://www.resist-cluster.de/en/) and the Peter L. Reichertz Institute for Medical Informatics of TU Braunschweig and Hannover Medical School (https://plri.de/en) have teamed up. The Master's program accepts 20 students each year, ten from each of the two groups.

3.2. The curriculum of Hannover Medical School's Master for Biomedical Data Science

Table 1 shows a simplified overview of our curriculum. Physicians and veterinarians are obliged to take fewer courses (90 ECTS) than students with a Bachelor's degree in biomedicine or life sciences (120 ECTS) due to their previous achievements in their study of human or veterinary medicine. Courses for physicians and veterinarians do contain a few days of on-site teaching and seminars but, in principle, are designed as online courses, while several additional courses for the second group are on-site events. The program starts with one week of on-site events, including a keynote by an expert of international renown in biomedical data science, introductions, e.g., to the learning management system, getting to know each other, technical installations, and first teaching.

Table 1. Overview of the curriculum for the Master's program in Biomedical Data Science at Hannover Medical School. In brackets, we have noted which courses are obligatory for physicians and veterinarians ('P') and for students with a life sciences degree ('LS').

Semester 1	Semester 2	Semester 3	Semester 4
Introduction to data	Microbial pathogens	Pathomechanisms of	
science (P/LS)	(LS)	infection (LS)	
Imaging of biological systems (LS)	Digital image analysis (P/LS)	Data protection, data safety and ethics (P/LS)	
Human genetics (LS)	Big data and Interoperability	Statistical machine learning	Master thesis
Clinical Trials and	(P/LS)	 AI and data analytics 	scientific reading,
biobanking (P/LS)	Biostatistics, omics	(P/LS)	writing and
Introduction to data	technologies and big data	Compulsory module II:	presentation
analytics (P/LS)	(P/LS)	applied data analysis	(P/LS)
Basics of computer	Compulsory module I:	(P/LS)	
science (P/LS)	applied data analysis (P/LS)		

3.3. Didactic concept outline

Key to our concept is that the students work intensively in interprofessional teams right from the start, and, therefore, the courses are designed in a flipped-classroom method to promote interprofessional communication and cooperation. Thereby a high degree of blended learning [4] has been implemented: In the central learning management system ILIAS, various learning material as video presentations, learning modules, data sets as well as exercises that are worked on alone or together are available online. In synchronous online or on-site sessions, usually held in the late afternoon, the knowledge can be deepened and applied in direct communication. Only courses with a high proportion of activities in the laboratory take place purely as attendance events.

The courses in Table 1 are complemented by additional courses that convey skills, e.g., interprofessional teamwork, self-management and media competency. Additionally, within the modules for applied data analysis, hands-on training of three months abroad is supported, using the international contacts of our lecturers, with funding options available. Furthermore, we have implemented a mentoring program by biomedical data science experts with a 3-1 supervision ratio.

3.4. Preliminary evaluation results

In our first Master's course, 18 students were enrolled, seven of which were medical doctors. In the first evaluation, the students gave us very positive feedback for the interdisciplinary group work, the interaction between students and lecturers and our means to foster this, a good working atmosphere in synchronous events, knowledge quizzes for self-assessment before exams and for unlocking the complete course materials already at the beginning of the courses, so that they could choose their learning slots for themselves.

Room for improvement was reported in terms of a more eclectic design of course materials, less heterogeneity in the workload between modules, high workload before exams and the demand for sample solutions for all exercises. Further suggestions for improvement include more interaction and practical work during on-site phases, hiring programming support tutors and further enhancements in synchronization between the modules' content.

Preliminary analyses of quantitative evaluations of all modules showed – on a scale from 0 (very bad) to 15 (excellent) – a median of 11 points. Adequate preparation time was reported in 67%, good alignment of synchronous and asynchronous course parts content-wise in 72% and temporally in 71%. The design of digital content was deemed as at least satisfactory in 83%. In 80% of feedback reports for all modules, the students stated that the modules had promoted their interprofessional thinking.

4. Discussion

The authors present the concept of a new Master's program for Biomedical Data Science, which stresses interprofessional learning and collaboration from the beginning, by mixing students with largely different backgrounds in learning groups. To enable the group of medical doctors to embark on this journey alongside their jobs, we created a curriculum with courses that allow for flexible, primarily online learning with a mix of several synchronous and asynchronous learning offers. We perceive, by and large,

assured by the feedback of our students that our approach has distinct benefits with regard to self-determined and flexible learning, part-time option, short, interactive on-site course parts, problem-oriented, practical and direct learning with excellent high-level researchers, teamwork, close contact with teachers and fellow students despite physical distance and close-knit mentoring [5]. Our results also show room for improvement in terms of synchronization between modules, workload distribution and design of course materials. These points of criticism are not entirely surprising, given that this was the first cycle of modules. This feedback will spark off readjustments, some of which we have already implemented, e.g., by adding two student tutors for supporting programming exercises in Python and R.

We are convinced that our program can contribute to educating students who obtain vital skills for working in the challenging environment of biomedical data science in medicine and biomedical research, among them sound domain knowledge as well as communication and interprofessional teamwork skills. Our study option for medical doctors, meeting them 'halfway', may serve to unlock the potential of this group of experts to join the field of biomedical data science and plan, design and lead future data-driven research projects. Finally, we believe that our graduates will be well-prepared for their professional careers in this quickly growing and relevant domain.

5. Conclusion

The authors present the concept of and first experiences with a new Master's program for Biomedical Data Science at Hannover Medical School in Germany. First experiences and preliminary evaluation show that the approach is overall well-accepted by our students and that it may serve to attract more medical doctors to this field.

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