Editorial

TJ Tumori Journal

Tumori Journal
2022, Vol. 108(1) 6–11

DOI: 10.1177/03008916211047268
journals.sagepub.com/home/tmj
SAGE

Biomedical omics: first insights of a new MSc degree of the University of Milan

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Abstract

The advent of technologies allowing the global analysis of biological phenomena, referred to as "omics" (genomics, epigenomics, proteomics, metabolomics, microbiomics, radiomics, and radiogenomics), has revolutionized the study of human diseases and traced the path for quantitative personalized medicine. The newly inaugurated Master of Science Program in Biomedical Omics of the University of Milan, Italy, aims at addressing the unmet need to create professionals with a broad understanding of omics disciplines. The course is structured over 2 years and admits students with a bachelor's degree in biotechnology, biology, chemistry, or pharmaceutical sciences. All teaching activities are fully held in English. A total of nine students enrolled in the first academic year and attended the courses of radiomics, genomics and epigenomics, proteomics, and high-throughput screenings, and their feedback was evaluated by means of an online questionnaire. Faculty with different backgrounds were recruited according to the subject. Due to restrictions imposed by the coronavirus disease 2019 (COVID-19) pandemic, laboratory activities were temporarily suspended, while lectures, journal clubs, and examinations were mainly held online. After the end of the first semester, despite the difficulties brought on by the COVID-19 pandemic, the course overall met the expectations of the students, specifically regarding teaching effectiveness, interpersonal interactions with the lecturers, and courses organization. Future efforts will be undertaken to better calibrate the overall workload of the course and to implement the most relevant suggestions from the students together with omics science evolution in order to guarantee state-of-the-art omics teaching and to prepare future omics specialists.

Keywords

Clinical education, postgraduate training, omics

Date received: 23 July 2021; revised: 2 August 2021; accepted: 3 august 2021

Introduction

Sequencing of the human genome opened a new era of biomedicine that will lead to an unprecedented revolution in the understanding of diseases and, consequently, in prevention and treatment strategies as well as in healthcare system organization. The founding element of this revolution is the possibility to decode diseases on the basis of causal genetic and environmental mechanisms. The most striking practical application is the development of treatment modalities exploiting agents that act directly on the molecular mechanisms implicated in disease and the quantification of genetic and environmental risk (precision medicine). The impact of precision medicine is most evident in oncology. Numerous drugs targeting specific genomic alterations or immune surveillance mechanisms responsible for tumor growth (targeted and immune therapies) are employed

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routinely in cancer therapy and have radically changed the natural history of specific tumor types.

One of the critical features of tailored treatments is the possibility to quantify biological or clinical phenotypes through so-called "omics" analyses (genomics, epigenomics, proteomics, metabolomics, microbiomics, immunomics, digital imaging, radiomics, and radiogenomics). The availability of quantitative analysis tools favors the transfer of disease risk assessment from a population to an individual and the choice of treatment from disease to patient (personalized medicine). Omics analyses have, therefore, pervaded the scientific approach in industry,[1] in both basic and clinical research,[2] and in routine clinical diagnostics,[3,4] including recent coronavirus disease 2019 (COVID-19) pandemic research.[5] The availability of a large amount of data as well as the development of new methodologies for their analysis, including artificial intelligence and machine learning,[6] have encouraged most hospitals and research institutions (both academic and industrial) to set up laboratories dedicated to omics analyses.

The staff employed in such laboratories is expected to perform extremely complex and specialized tasks, including: understanding the scientific/clinical question at the basis of the requested analyses in order to select appropriate laboratory protocols; carrying out the selected omics analysis; and interpreting results in order to evaluate whether the analyses answered the scientific questions posed (and possibly modify the protocols used for the analysis itself). Moreover, they must adapt standard protocols to local scientific and logistic needs, and incorporate continuous technological advances in the field.

The members of omics laboratories are generally researchers that decide to work in this emerging field. This solution is not always optimal and there is growing demand for expert personnel. Although the required skills are specialized and complex, there are not many university courses specifically designed to train professionals in omics sciences.

The Master's Degree in Biomedical Omics has been designed with the aim of filling this gap. It is an international program organized by the Department of Oncology and Hemato-oncology of the University of Milan, Italy. The course aims to train specialists in omics technologies who will work in clinical or research omics laboratories or biotech companies. Accordingly, graduates will develop key competences including the ability to design experiments, manage workflow, analyze and interpret omics data, as well as create applications for future developments in omics approaches in the medical field.

The Master's Degree in Biomedical Omics was promoted through a press conference held in March 2020 and has a dedicated web site.[7] The Master's program was approved by the Senate of the University of Milan on January 14, 2020, and started in the academic year 2020–2021.

Faculty includes university professors and international omics experts and all activities are held in English. The program recruits a maximum of 35 students a year. Candidates must hold a Bachelor's degree in biology, biotechnology, chemistry, or pharmaceutical sciences. Students are exposed to the international community of omics scientists and teachers and participate in laboratory activities and become familiar with medical diagnostic pipelines. Technology transfer, legal, and social implications of omics data generation and science communication, including specific training in public speaking, medical writing, and scientific presentation, are also fostered.

Due to the COVID-19 pandemic, laboratory activities were temporarily suspended during the first semester, while lectures, journal clubs, and tests were mainly held online (via Microsoft Teams). All lessons have been videorecorded and made available asynchronously.

The University of Milan takes part in the European Erasmus+ program to favor the international mobility of its students, offering them the opportunity to spend periods of study and internship abroad, in order to enrich their curriculum in an international context.

Course novelty

To our knowledge, there are only two courses worldwide with similar characteristics: the Master of Science program in Bioinformatics/Omics Data Analysis at the Universitat de Vic–Universitat Central de Catalunya, in Spain,[8] whose purpose is to train professionals to perform omics analyses; and the Master of Science in Genetics and Multiomics at the University College of London, UK.[9] In both courses, radiomics is not part of the educational offering, despite its growing relevance. In other cases, omics technologies represent individual modules of Master's programs[10] or postgraduate certificates.[11] A summary of the characteristics of the three courses, including the one presented here, is reported in Table 1.

Educational activities

The course is divided into three types of educational activities: theoretical, laboratory, and clinical. Theoretical educational activities include lecture series delivered by professors, lecture series obtained from web resources (i.e. webinars), thematic seminars held by invited professors, and omics journal clubs. At the end of each webinar and seminar, the students prepare a short journal club as

Table 1. Master of Science degrees in omics worldwide.

	Biomedical Omics	Omics Data Analysis	Genetics and Multiomics in Medicine
University	University of Milan	Universitat de Vic	University College London
Country	Italy	Spain	UK
Year of institution	2020	2021	2021
Language of instruction	English	English	English
Maximum number of enrollable students per year	30 + 5[a]	25	NA
Academic years	2	1	NA
ECTS credits	120	60	NA
Requirements for enrollment	Bachelor's degree in biotechnology, biology, chemistry, or pharmaceutical sciences	A degree in biotechnology, biochemistry, biology, genetics, microbiology or biomedical science; accredited B2 level of English according to the CEFR	Wide range of backgrounds, from scientists and statisticians to computer professionals and clinicians
Main topics covered by the programme	Clinical omics, genomics and epigenomics, proteomics, radiomics	Applications, bioinformatics, epigenomics, genomics, interactomics, proteomics, transcriptomics	Genomics, transcriptomics, proteomics, phenomics
Tuition fees	Free	€5,642.00 (taxes included)	NA
Website	unimi.it/en/education/biomedical-omics-bo	uvic.cat/en/master-degree/omics-data-analysis	ucl.ac.uk/medical-sciences/study/postgraduate-taught-programmes/genetics-and-multiomics-medicine-msc

ECTS: European Credit Transfer and Accumulation System.
[a]Reserved for non–European Union citizens.

well, and all journal clubs are part of the evaluation process. Laboratory and nonformal academic activities represent additional educational activities, which can be either mandatory or elective according to the semester. Each laboratory activity ends with the students preparing a report on the activities carried out as well as a scientific publication on the topic. The so-called Friday Students Days are selected Fridays in which the students are expected to deliver presentation to their colleagues concerning the omics, webinar and seminar journal clubs, data reports on practical activities, and omics-lab journal clubs. These activities are mandatory and are part of the final evaluation.

Evaluation process

Each course is coordinated by one or more professors and includes all types of educational activities, as described above (lectures, seminars, practicals, journal clubs, etc.). Such activities are mandatory and students cannot access the final examination unless all activities have been completed and evaluated by the respective faculty members.

Each course is followed by an examination, usually a written or an oral test (or a combination). Course examinations must be passed, with grades calculated on a 30-point scale, to obtain course credits, with 18/30 being the minimum pass grade.

The final mark will take into consideration the following criteria: performance at Friday Student Days (quality, punctuality); laboratory activities (as assessed by laboratory tutors and faculty members); data report on practical activities; and examination (written or oral, as chosen by the responsible faculty members).

Topics

The first-year courses cover omics technologies and their applications, computational approaches for analysis, interpretation and management of omics data, legal implications of omics analyses, laboratory management, and technology transfer. In the second year, the students study the application of omics technologies in diagnostic and clinical settings, experimental design, and ethical issues concerning the use of omics in a clinical setting. The second year is also dedicated to the production of an experimental thesis deriving from a research project. The national and international laboratories where students can carry out their thesis projects are selected on the basis of quality. The main topics covered by the program and the educational activities are presented in Figure 1 and Table 2.

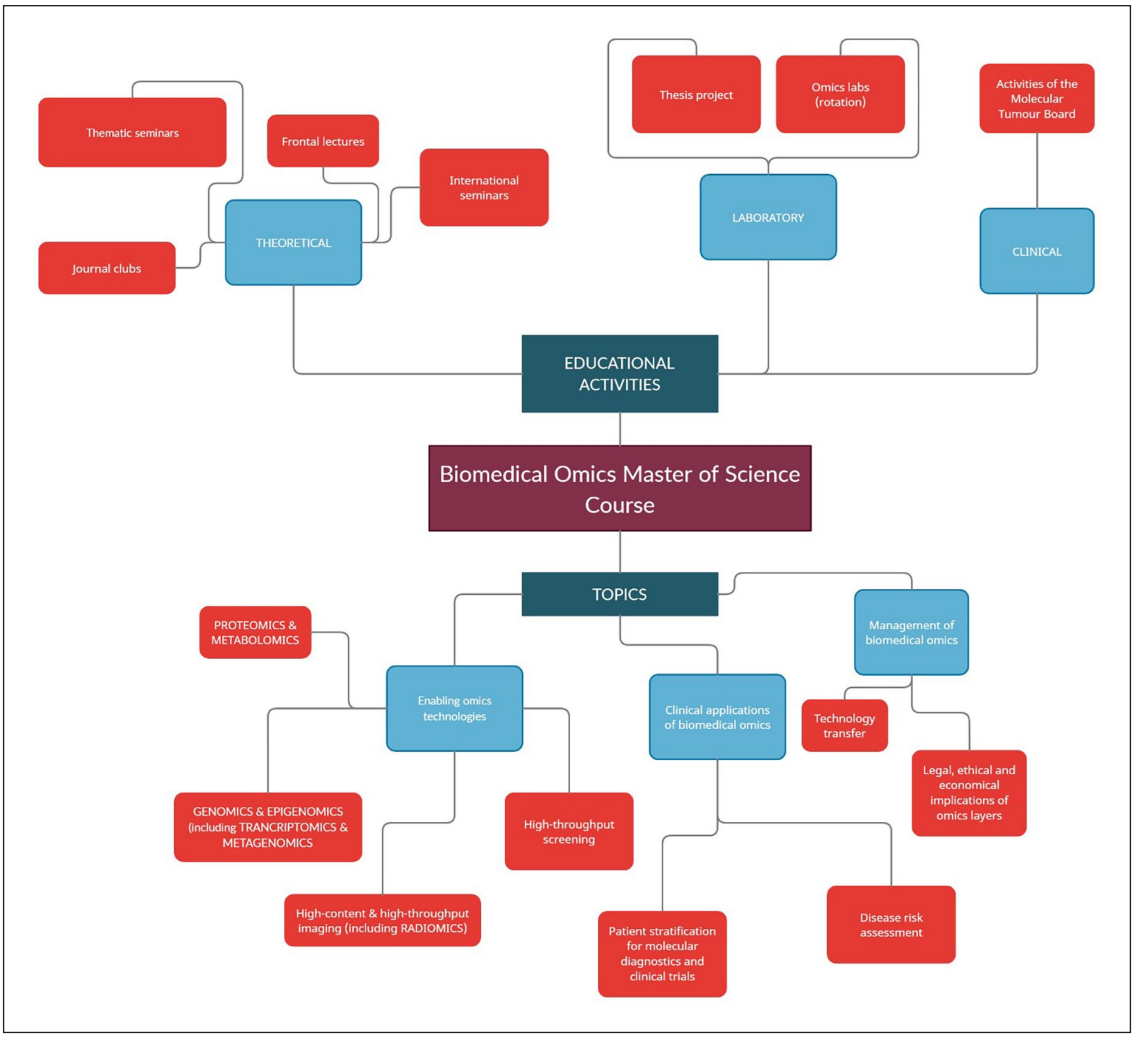

Figure 1. The organization of the biomedical omics Master of Science at the University of Milan.

The course from the student's perspective

A total of nine students enrolled in the first academic year and attended the courses of radiomics, genomics and epigenomics, proteomics, and high-throughput screenings. The opinion of the students on this new course was evaluated by means of a questionnaire that was administered to the students. Notwithstanding the large number of lecturers in the first semester, 70% of students evaluated the coordination among courses as good or very good and the overall teaching effectiveness as very good or excellent. Interaction with the lecturers was judged to be either very good or excellent according to all students. The level of proposed lecturers was excellent according to 70% of participants. All students but one agreed on the usefulness of seminars, webinars, and Student Days. The workload of the first semester was judged as heavy by all students, and accordingly, 90% of students found the first semester challenging. Overall, the classes met the expectations of all students, with different degrees of satisfaction.

The questionnaire allowed respondents to provide additional comments on the course, which were mostly positive and enthusiastic. Students found that the teaching activities were engaging and effective, and in general enjoyed the seminars, journal clubs, and working in teams. They pointed out some redundancies among the different courses, which were, however, considered helpful by most students.

Conclusions

The innovative Master of Science Program in Biomedical Omics was designed to cover the unmet need of training specialists in omics technologies, who will work in clinical or research laboratories or biotech companies. Despite the difficulties brought on by the COVID-19 pandemic, the course achieved positive feedback from all participants at the end of the first semester, especially concerning teaching effectiveness, interpersonal interactions with the lecturers, and course organization. Future efforts will focus on ensuring appropriate professional placement of all graduates.

Table 2. Biomedical omics Master of Science (University of Milan) course list.

Course	Maximum ECTS	Hours	Period	Language	AD
Additional language skills: Italian (3 ECTS)	3	0	Undefined	Italian	
clinical omics	6	48	First semester	English	MED/06 MED/11 MED/15
Computational approaches for omics data	12	96	Second semester	English	INF/01 ING-INF/05
Ethics and decision-making	6	48	First semester	English	M-PSI/01
Experimental design	6	48	First semester	English	BIO/11 MED/04
Final exam	28	0	Undefined	English	
Genomics and epigenomics	12	144	First semester	English	BIO/10 BIO/11 MED/04
High-throughput screenings	6	56	First semester	English	MED/04
Legislation, management, and technology transfer	12	136	Second semester	English	MED/43 MED/46
Omics in diagnostics	6	48	First semester	English	MED/03 MED/08
Practical laboratory activities	6	96	year	English	
Proteomics	6	56	First semester	English	BIO/10
Radiomics	6	48	First semester	English	MED/04 MED/36

AD: academic discipline for Italian university research and teaching; ECTS: European Credit Transfer and Accumulation System.
BIO/10: Biochemistry
BIO/11: Molecular biology
INF/01: Informatics
ING-INF/05: Information processing systems
MED/03: Medical genetics
MED/04: Experimental medicine and pathophysiology
MED/06: Medical oncology
MED/08: Pathology
MED/11: Cardiovascular diseases
MED 15: Blood diseases
MED/36: Diagnostic imaging and radiotherapy
MED/43: Forensic medicine
MED/46: Medical and biotechnology laboratory techniques
M-PSI/01: General psychology

Author's note

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Acknowledgements

S.V. is a PhD student within the European School of Molecular Medicine (SEMM), Milan, Italy. M.Z. received a research grant by the European Institute of Oncology–Cardiologic Center Monzino Foundation (FIEO-CCM), with a project titled "Proton therapy vs photon-based IMRT for parotid gland tumors: a model based approach with normal tissue complication probability (NTCP)," outside the current study.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was funded by the University of Milan and by the Department of Oncology and Hemato-Oncology of the University of Milan, Italy. The sponsor was not involved in the study design, collection, analysis, interpretation of data, the writing of this article, or the decision to submit it for publication.

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