



BRIEF REPORT

Review of applied health informatics courses in a multidisciplinary biomedical informatics department

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Abstract

Introduction: Applied health informatics infrastructure is a requirement for learning health systems and it is imperative that we train a workforce that can support this infrastructure. Our department offers courses in several interdisciplinary programs with topics ranging from bioinformatics to population health informatics. Due to changes in the field and our faculty members, we sought to assess our courses relevant to applied health informatics.

Methods: In this paper, we discuss the three-phase evaluation of our program and include the survey we developed to identify the skills and knowledge base of our faculty.

Results: We show how this assessment allowed us to identify gaps and develop strategies for program expansion.

Conclusions: A focus on workforce development can help to guide and focus curricular review in an interdisciplinary graduate program.

KEYWORDS

Bloom's taxonomy, competencies, curriculum, health informatics

1 | INTRODUCTION

In order to support the informatics infrastructure of a learning health system, we need a well-trained workforce in applied health informatics. At The Ohio State University's Department of Biomedical Informatics (BMI), we have a multidisciplinary group of faculty with expertise spanning bioinformatics to public health informatics. These faculty offer graduate-level courses in the area of clinical/health informatics in multiple programs, including an online graduate certificate program, an interdisciplinary master's degree program in partnership with the College of Public Health, and a PhD program through the College of Medicine. The certificate program is organized into specialization tracts including clinical informatics, clinical research informatics, health analytics, and translational bioinformatics. The master's and

PhD programs cover the breadth of biomedical informatics in required courses and allow students to further specialize through elective courses. Although none of these programs are specifically focused on applied health informatics or learning healthcare systems, they do focus on training workforce that will directly participate in learning health systems as technical and informatics experts and leaders. However, the foundation of these programs is based on courses developed almost a decade ago, with additional courses added based on the evolving needs of the field and expertise of the teaching faculty within the department. To continue to evolve and meet the demands of the growing informatics workforce, we recognized a need to review our curriculum.

There are multiple sources that can help guide an informatics program in developing and reviewing their curriculum. The Agency for

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Healthcare Research and Quality has outlined the competencies and training required for a learning healthcare system,¹ including the informatics domain of this system. Published reports have also evaluated and/or recommended core competencies and curriculum requirements for training workforce in clinical and health informatics.²⁻⁵ Programs in health informatics and health information management can undergo accreditation through the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM).⁶ However, for a program such as ours that falls outside of these well-established descriptions, it can be challenging to ensure that core competencies are covered and necessary skills are being developed.

Due to changes in the field and in our faculty, as well as new and evolving recommendations, we underwent a formal curriculum review for graduate-level applied health informatics courses in our department.

2 | THE ROLE OF INFORMATICS IN A LEARNING HEALTH SYSTEM

A learning health system requires the collection and use of data to inform needed practice change, and in many cases, relies on health information technology (HIT) to put new practices into place. In fact, informatics is called out by AHRQ as one of the eight key domains of learning health systems¹ and technology was listed as one of the core components of a learning health system in an academic health center by Kraft and colleagues.⁷ A successful learning health system will require a broad interdisciplinary workforce, but it is clear that the discipline of applied health informatics is one of the necessary and crucial disciplines. The informatics workforce includes clinical informatics leadership (eg, Chief Medical Information Officers), data analysts, software developers, and industry leaders, among others. A better understanding of the applied informatics competencies that underpin an effective learning health system is a crucial first step to building this workforce.

3 | QUESTION OF INTEREST

How can an applied informatics curriculum evolve to meet the changing needs of the learning health system workforce while simultaneously capitalizing on the strengths of the faculty and institution?

4 | METHODS

Our educational program was tasked with reviewing the clinical informatics curriculum. Prior to meeting with relevant faculty, we outlined a general plan based on a previous review of the bioinformatics curriculum at our institution and feedback from a department retreat.

Our first challenge was to identify faculty stakeholders. As a multidisciplinary department with faculty expertise in many different areas under the umbrella of biomedical informatics, we reached out broadly to ensure that we had appropriate representation. The final working group included faculty with expertise in the fields of health services

research, population health, clinical informatics, patient preferences, artificial intelligence/machine learning, and clinical data re-use.

Prior to starting the discussion, we evaluated what we should name this area. The initial subject area was identified as clinical informatics, but this term did not seem to reflect the faculty's broader interests in public health and population health, and the emphasis on implementation to support a learning health system. The group agreed upon the title of "Applied Health Informatics". While the primary goal was to identify potential gaps in applied health informatics education in BMI, the course review would also help identify any overlap in content, create a pathway for students interested in applied health informatics, and propose new courses to close identified gaps.

There were three phases to our plan. In phase 1, we completed a literature review of published clinical and applied health informatics curricula.^{1-3,5,8,9} From this review, we identified and came to an agreement on general themes and subcategories of topics that should be covered in our applied health informatics curriculum. In phase 2, based on the review of the syllabi and learning objectives of our courses, we created a matrix by mapping the topics covered in the courses to the themes and subcategories identified from the literature. We used the original Bloom's taxonomy, a hierarchical model commonly used to classify educational learning objectives by their complexity and specificity,¹⁰ to identify at which level of complexity, each subcategory was being offered for each course. Finally, we used this information to create a summary of the subcategories that were covered or not covered in our current courses. If covered, we recorded the highest level of Bloom's taxonomy at which they were covered. In Phase 3, we were able to use this matrix and the summary to identify gaps and overlaps in our current curriculum. For the topics that overlapped between multiple courses, we reviewed the syllabi and discussed the exact content and context of the topic with the respective course directors to determine if changes needed to be made.

To address gaps and determine additional courses that we could offer, we realized we needed to better understand the expertise and comfort level of our faculty for teaching different subjects. For that reason, we developed and sent out an online survey to relevant faculty in our department. The survey included questions about faculty expertise in eight major topic areas: (a) patient engagement, preferences, and decision-making, (b) technology and informatics systems/clinical information systems/public health information systems, (c) developing and evaluating tools, (d) implementation, (e) quality improvement, (f) public health, (g) methods and data analysis, and (h) statistical languages and programs (see Supplementary material for the full survey).

5 | RESULTS

Our work resulted in multiple products. The first was a list of general themes, subcategories, and topics in applied health informatics. The second was a matrix of topics mapped to each course and the level of complexity as per Bloom's taxonomy. The third was the survey result indicating faculty interests and knowledgebase.

5.1 | Themes

The major themes identified through discussions and literature review to be of importance in our applied health informatics curriculum were:

- Clinical Data
- Clinical Decision Making
- Clinical Research Informatics
- Computer Science/Data Science
- Discipline of Clinical Informatics
- Health System/Clinical Care
- Health/Public Health Information Systems
- Implementation Science

Several subcategories and specific topics within those subcategories were also identified (see Supplementary material).

5.2 | Matrix and assessment of gaps and overlap

Currently, a total of six courses are offered in these areas. Additionally, we offer an introductory course that provides an overview of the many different areas of Biomedical Informatics, including applied health informatics.

In reviewing the topics covered in each course, we identified a few areas of overlap. For example, two courses had assignments that utilized the same business intelligence software to create visualizations and dashboards. These were investigated and found to be reinforcing, rather than duplicating, instruction. We also noted that multiple classes discussed topics of ethics, but as these were discussed in different contexts and were considered to be important topics, we agreed the overlap was appropriate.

The gaps identified included topics in Computer Science/Data Science, Health System/Clinical Care, Clinical Data, Clinical Decision Making, and Implementation Science (see Supplementary materials for detailed categories, subcategories, topics, and highest Bloom's taxonomy levels assigned). It is important to note that many of the topics that we classified as "NOT COVERED" in our matrix, are likely covered by courses outside our department within our interdisciplinary graduate programs. For example, programming languages, data structures, and algorithms under the Computer Science/Data Science theme are available through The Ohio State University Department of Computer Science and Engineering. However, since these courses are currently offered as electives, it is more challenging to keep track of relevant competencies they offer across the Health Informatics curriculum. First, without detailed review of the syllabi of each elective course, it is difficult for us to assess the specific competencies they cover. Second, while we can determine the electives that our students have selected, the fact that these are electives means that not all students are gaining the competencies they cover. Understanding that the topics covered by these courses are integral to workforce training for learning healthcare systems, we will consider adding these courses as requirements or recommendations in the future. We are working on better incorporating

TABLE 1 Distribution of identified applied health informatics topics in reviewed curriculum over Bloom's taxonomy levels

Bloom's taxonomy complexity level	Percentage of topics
Knowledge	11.5%
Comprehension	46.0%
Application	17.2%
Analysis	5.8%
Synthesis	5.8%
Evaluation	2.3%
NOT COVERED	11.5%

available educational analytics tools into our program, which will hopefully help us to better track outcomes and competencies.

Based on a summarization of Bloom's taxonomy levels, we not only identified gaps but also noticed that majority of the topics were covered at the level of comprehension with few topics covered at higher levels of the taxonomy (Analysis, Synthesis, and Evaluation) (Table 1). We also observed that there were very few topics where a higher-level course built upon on a lower-level course. Some of the categories that we identified as needing higher-level instruction included secondary use of clinical data and application of Computer Science/Data Science methods, specifically artificial intelligence/machine learning (AI/ML), natural language processing, and imaging analytics. The first of these will be addressed by a new course on the re-use of clinical data, specifically electronic health record (EHR) data. The others will, at least in part, be covered by courses being created for an innovative AI/ML certificate program, which is being developed in collaboration with The Ohio State University Department of Computer Science and Engineering. These courses include AI/ML in predictive analytics and electronic health records, natural language processing of clinical notes, and medical image analytics for radiology and pathology. We also identified that one of the lower-level courses covered topics at a higher level of Bloom's taxonomy and we are considering making it a higher-level course in our series.

5.3 | Faculty expertise and future planning

The survey was completed by nine faculty members, all of whom were part of the working group. We found that we have an accomplished group with diverse expertise. All topics surveyed had at least one faculty member who felt they were well-versed in the area. This information will help us bridge the gaps that we identified in our current set of courses (described above) and in the future program expansion.

We identified areas of growth for applied health informatics in our department. We proposed to re-vamp the current certificate and course offerings to allow for more flexibility and customization for those interested in applied health informatics by providing a broader spectrum of topics and higher-level courses covering specific topics in depth (at higher Bloom's taxonomy levels).

6 | DISCUSSION

We have described here the review process that our department's educational program underwent to ensure that we were evolving our course work to meet the changing needs of the workforce, and that our students would benefit from the varied expertise of our faculty in our highly multidisciplinary department. Multiple faculty hold joint appointments in the Department of Computer Science and Engineering, Department of Internal Medicine, College of Public Health, and others. Our work resulted in a survey of faculty expertise, which has also been useful in helping us to identify appropriate advisors for students. Additionally, we now have each of our courses mapped to themes, subcategories, and specific topics, which allows for better ability to track changes across the program.

AHRQ-led efforts to develop learning health system core competencies have identified Informatics as one of the eight core competency domains.¹ This work allowed us to assess how our program can support workforce training for a Learning Health System. Our applied health informatics curriculum maps closely to all the competencies listed under the informatics domain (see shaded topics within Supplementary Table). In addition, our curriculum covers some competencies in other domains highlighted by AHRQ including research methods, implementation science, and ethics. We recognize that a successful LHS will need an interdisciplinary workforce with training and expertise across the eight core domains identified by AHRQ. Our program focuses on training experts in informatics, who will be able to collaborate with those trained in other domains.

This work has several limitations. We only reviewed the courses that are offered in our department and are taught by our faculty. However, most of our students are in interdisciplinary programs and benefit from courses in other departments and colleges as well. Our next step in this process will be to assess which of our gaps are covered by these other courses, and at which instructional level we may want to offer them in our own courses. In addition, for simplicity, and due to the preference of our faculty at the time, we chose to use the original Bloom's taxonomy rather than the revised version. However, we plan to reassess transitioning to the revised taxonomy for our next update. Finally, our literature review was to help guide us, and provide examples, but was not systematic or exhaustive. We plan to continue reviewing literature in this area as well as evaluating our own program compared to similar ones at other institutions.

In Table 2, we outline the major challenges and potential solutions identified during our review process. There were several challenges that are worth noting. Students interested in applied health informatics generally come from either a health/public health background or a computational background. For those with no prior computational background, we have struggled to ensure that they have these skills by the end of the program. Technical skills are conventionally taught in undergraduate programs, not initiated in graduate programs. If starting in graduate school, graduate-level computer science courses can be challenging for students without a computational background. One solution is to develop graduate-level computing courses specifically for students with no computational educational background. These courses should focus on the application of existing tools and methods rather than method development. We have collaborated

TABLE 2 Challenges identified during the curriculum review and potential solutions

Challenges	Description	Potential solutions
Diverse faculty expertise	Multidisciplinary department—evolving expertise	Developed survey to better identify faculty members' nuanced areas of expertise
Evolving field	Rapidly evolving field with increased focus on artificial intelligence, need for technical skills, etc.	Frequent reassessments of curriculum, feedback from graduated students, and market surveys to identify new skill training that should be offered
Moving toward more micro-credentials/certificates	Little guidance on curriculum development for certificates	Created process to facilitate quick review of courses/faculty to create new certificate programs
Students without basic introductory computational training	Students often come from health or public health backgrounds, without advanced computational skills	Collaborate with other colleges to co-develop graduate-level introductory computational courses
Lack of access to clinical areas for students	Students are not able to access clinical systems and patient data due to security/privacy policies	Creating mock patient datasets, Subject matter expert (SME) reviews of student work, and SME guest lectures. Work collaboratively with colleagues in the clinical space to create potential opportunities for hands-on training

with our computer science colleagues at the university to fill this gap by offering a new course targeted at teaching introductory programming for informatics students.

Another challenge is in making the move toward more certificates or micro-credentials. Offering these is especially useful for professionals who are looking for additional skill development. However, there is little guidance for how to develop and review these programs. By organizing our courses in a matrix format with topics and hierarchical levels of complexity of instruction, we are better prepared to ensure that our courses are covering the desired competencies. We can also use this to easily identify and develop new certificate programs.

We did not focus only on the workforce needs of a learning health system, but more broadly on the informatics needs of health-care. This gives our students the flexibility to pursue a variety of careers, but also complicates identifying necessary competencies.

Finally, it is a challenge that our students have limited access to clinical areas and operational systems. We have addressed this in

multiple ways and continue to discuss strategies to give more hands-on experience. For our research informatics course, we developed synthetic patient data that students can use in analyses, visualizations, and for developing research questions and hypotheses. We plan to create a larger dataset to mimic EHR data for our EHR data re-use course. In our existing clinical informatics course, our students design a clinical decision support tool prototype. Clinical and operational experts at our institution engage in subject matter expert reviews of these tools to show the students what kind of feedback to expect in the clinical space. The continued evolution of our course content toward hands-on activities will provide our students with real-world experience. This will not only better prepare them for their careers, but also contribute to a workforce that will help transition us toward a learning health system.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Motiwala T, Zhang P, Gregory M, et al. Review of applied health informatics courses in a multidisciplinary biomedical informatics department. *Learn Health Sys*. 2022;6(4):e10336. doi:10.1002/lrh2.10336