New Orleans JAZZED about Engineering Education

Paper ID #15420

Toward Engineering-Oriented Health Informatics Education

Dr. D. Cenk Erdil, Marist College

Dr. Erdil is an Assistant Professor of Computer Science at Marist College. He has been designing and teaching general computer science courses for more than a decade. He has also contributed to the design and management of several computer science and engineering programs as a program coordinator. His research interests include K-12 STEM education, distributed resource scheduling, cloud computing for big data, public health informatics, and mHealth. Prior to joining Marist, he was an Associate Research Scientist at Columbia University Medical Center, working on research and implementation projects as a senior Information and Communication Technologies lead in various U.S. CDC-funded multi-year research grants in public health informatics. His current research grants study mobile data collection in cloud-based health informatics infrastructures.

Toward Engineering-Oriented Health Informatics Education

Abstract

The need for informatics-trained professionals in health organizations has been ever-increasing. In addition, there is also a significant need to orchestrate data collection through informatics infrastructure, manage computing resources, store data, and operate network-enabled medical devices. In many medical fields, the overall need for supporting advanced medical devices with complex technological requirements is also exponentially increasing.

Existing undergraduate major and minor programs in health informatics do not adequately equip students with skills to address these challenges, mostly due to limited STEM-focused courses. There is an increasing gap between overall skill-set of graduating health informatics professionals, and the job requirements. It takes a long time to train these individuals on the field, and equip them with necessary informatics skills to address these challenges.

This skills gap has traditionally been addressed by employing graduates with computer science and engineering degrees. However, professionals with health informatics degrees, and computer science and engineering degrees each approach problems differently from their particular perspective(s), and resulting multidisciplinary teams can only provide short-term solutions. Thus, resulting data architectures and support infrastructures are both inefficient and incomplete in most cases.

This article provides a basic analysis of twelve existing health informatics undergraduate major programs, and proposes a more STEM-focused, engineering-oriented degree options to *complement* these programs to help narrow the skills gap. In particular, we argue that at least *some* of the health informatics professionals on-the-field should be provided opportunities—during their undergraduate education—to (i) have hands-on coding skills at more advanced levels, (ii) be aware of how to orchestrate data and computational infrastructures, and (iii) know about contemporary tools and methods to analyze large datasets efficiently.

1 Introduction

Health Informatics is a translational discipline at-large. With recent popularity of big data in almost every single health informatics field, from bioinformatics and medical informatics, to public health, two particular skill sets have become increasingly important to train professionals in these fields to deal with big data: (i) data analysis, and (ii) computational sciences. While most

health informatics programs have included courses to equip students with relevant data analysis skills, the same cannot be easily stated for the computational sciences, resulting a widened skills gap in health informatics professionals. Previously, we have highlighted this skills gap from the perspective of graduate degrees in health-related backgrounds.[1]

Another aspect of this widened skills gap, however, can be stated and analyzed from a computer science and engineering perspective. Several state-of-the-art, high-quality tools, both open-source and proprietary, have been developed and are used for almost more than a decade in various health informatics fields, to address the operational aspects of handling medical and health-related data.[2,3,4] These tools, most of which have been developed with a particular focus in resource-limited settings (e.g. Sub-Saharan Africa), can efficiently address the organizational needs of many medical and health facilities, when properly installed and configured. There haven't been any general-purpose, streamlined solutions, however, to address the interoperability and cross-organizational requirements of the plethora of many different medical and health facilities, with their complex organizational structures, and reporting needs to several different institutions (both local and regional authorities, and also funding organizations).

This version of the skills gap, we believe, is in part due to the lack of relevant academic content for graduates from computer science and engineering fields, in particular. Thus, an increase in medical and health-related courses in both senior- and graduate-level courses in information technology, and computer science and engineering disciplines, would provide proper training to narrow this field-specific skills gap in several different health informatics fields. This combination of courses would constitute unique, engineering-oriented, undergraduate degree programs, with a solid STEM foundation.

In this paper, we look at several leading undergraduate health informatics programs, and then suggest improvements in terms of both general course contents, and particular modules that can help narrow the mentioned skills gap. The rest of this paper is organized as follows. In Section 2, we outline the skills gap in health informatics, and discuss possible reasons for it. Section 3 presents an overview of existing undergraduate-level health informatics majors, and categories courses/credits into several main groups. Section 4 discusses the need for engineering-oriented health informatics programs. We conclude our remarks in Section 5.

2 Problem: The Skills Gap in Health Informatics

The need for better informatics-trained professionals in health organizations has been significantly increasing. For example, in public health, informatics professionals typically deal with collection, classification, archival, as well as reporting and representation of big data sets.[5,6] In addition, there is also a significant need to orchestrate collection of data from the field, commonly in resource-limited settings that encompass challenging infrastructure. Other demanding technology-oriented tasks include managing computing resources, dealing with distribution, operation, and security of mobile equipment and data collected on that equipment, operating network-enabled medical devices (blood testers, infusers, etc.). As we move into an Internet of Things (IoT) era, the need for supporting multiple unique medical devices with complex technological requirements is exponentially increasing.[7,8]

Almost none of these skills are among the objectives of existing undergraduate major and minor programs in health informatics. Thus, there is an increasing gap between overall skill-set of health informatics professionals graduating from these programs, and the job requirements of health informatics positions on the field. It takes months, if not years, to (i) train these individuals for the job requirements, and (ii) equip them with necessary informatics skills to address these challenges.

The need to support IT-related data and infrastructure have traditionally been addressed by employing graduates with computer science and engineering degrees, that equip students with relevant skills to address such challenges. There still exists, however, a visible skills gap in health informatics. That is, those with health informatics degrees and computer science and engineering degrees each approach problems from their particular perspective(s), and typically leave some of the issues unresolved, provide short-term solutions, or delay them to be resolved in the future. Thus, resulting data architectures and support infrastructures are both inefficient and incomplete in most cases. Looking from the other side, it also takes months, if not years, to bring computer scientists and engineers up-to-speed with particular needs of health informatics related data and informatics tasks.

Initiatives to introduce informatics and computer science skills *for every student* have been around for a while.[9,10,11,12,13] As these initiatives target future generations, we still need to act for the current and upcoming generation of engineering students who may be interested in a career in health and/or medical sciences. In an effort to help address the existing skills gap, we have looked at the existing undergraduate majors and minors across the United States in Section 3, and we have comme up with a set of requirements for engineering-oriented health informatics degree programs in Section 4.

3 A Closer Look at Health Informatics Programs

In this section, we look at some of the health informatics undergraduate major programs in the United States. We then classify courses offered in these programs based on their content into several categories. This categorization helps us better identify the skills gap from a computer science perspective. We then propose potential solutions to address this skills gap in the next section.

3.1 Undergraduate Programs in Health Informatics

A quick overview of undergraduate major programs in health informatics is given in Table 1. The programs are mainly divided into two categories: *online* and *traditional*[*].

We then look at the details of each program, in terms of the courses offered in each program. In particular, we categorize the courses as follows:

- COR: Common core of undergraduate studies, usually specified by degree granting units.

[*]Those programs in which *majority* of the courses are on-campus.

Table 1: Common health informatics undergraduate majors in the United States. All programs are on a semester-based academic schedule, around 120 credits on average, except Oregon Tech's program, which runs on a trimester schedule and has been adjusted to semester schedule (from 180 credits to 120 credits).

ID	Institution	Degree	Credits	Online
SJU	St. John's University[14]	B.Sc.	126	No
SC	Simmons College[15]	B.Sc.	120	No
GMU	George Mason University[16]	B.Sc.	120	No
EWU	Eastern Washington University[17]	B.Sc.	132	No
UW	University of Washington[18]	B.Sc.	130	No
GSU	Georgia State University[19]	B.I.S.	123	No
UIC	University of Illinois at Chicago[20]	B.Sc.	123	Yes
MT	Montana Tech[21]	B.Sc.	120	Yes
WGU	Western Governors University[22]	B.Sc.	120	Yes
UC	University of Cincinnati[23]	B.Sc.	120	Yes
CUNY	City University of New York[24]	B.Sc.	120	Yes
OT	Oregon Tech[25]	B.Sc.	120	Yes

- LIB: Other liberal arts courses/credits not in COR, but required by major.
- CSE: Computer Science and Engineering (and Information Technology) oriented courses.
- HIS: Health Informatics and Information Systems oriented courses.
- MED: Other health and medical sciences courses/credits, not in health informatics.
- OTH: Courses/credits not in any of the other categories.

Table 2 gives this categorization details of course offerings the programs listed in Table 1. Both in online and traditional programs, the common core courses/credits represent the largest group in all but two of the programs. Combined together with other liberal arts category, and the courses in the *other* category, non-degree oriented courses constitute the majority in all the programs.

Table 3 shows percentage values for each category, for the health informatics majors listed in Table 2, calculated as a ratio of the number of credits in each category, to the total credits offered in each program. Programs with variable / optional credits are set to their minimum possible values, respectively, for percentage calculations.

3.2 Online vs. Traditional Programs

Figure 1 depicts an overall comparison of percentages of course categories, averaged over all health informatics majors. As we have two main groups of majors in health informatics, that is, online and traditional programs, we want to compare the category breakdown in each group. Figure 2 then shows a similar comparison of each category, for three different cases: all programs, online programs, and traditional programs.

Although there does not seem to be a large-scale difference between the two, we highlight that the

Table 2: Categorical breakdown of course offerings in health informatics programs in the United States. Each column shows course credit amounts, respectively. Programs with variable credits are set to their minimum possible credits, respectively.

ID	Credits	COR	LIB	CSE	HIS	MED	OTH
SJU	126	42	21	21	15	18	9
SC	120	64	3	21	12	3	17
GMU	120	38	9	6	49	9	9
EWU	132	36	24	20	18	18	16
UW	130	65	0	15	28	22	0
GSU	123	60	0	6	30	24	3
UIC	123	45	15	7	43	13	0
MT	120	32	12	15	42	15	4
WGU	120	50	14	14	15	20	7
UC	120	60	5	3	15	34	3
CUNY	120	39	0	12	32	22	15
OT	120	44	9	17	28	12	10

Table 3: Percentages of each of the six course categories for the programs in Table 2, as a ratio of total credits in each category, over total number of credits in each program.

ID	COR%	LIB%	CSE%	HIS%	MED%	OTH%
SJU	33.33	16.67	16.67	11.90	14.29	7.14
SC	53.33	2.50	17.50	10.00	2.50	14.17
GMU	31.67	7.50	5.00	40.83	7.50	7.50
EWU	27.27	18.18	15.15	13.64	13.64	12.12
UW	50.00	0.00	11.54	21.54	16.92	0.00
GSU	48.78	0.00	4.88	24.39	19.51	2.44
UIC	36.59	12.20	5.69	34.96	10.57	0.00
MT	26.67	10.00	12.50	35.00	12.50	3.33
WGU	41.67	11.67	11.67	12.50	16.67	5.83
UC	50.00	4.17	2.50	12.50	28.33	2.50
CUNY	32.50	0.00	10.00	26.67	18.33	12.50
OT	36.67	7.50	14.17	23.33	10.00	8.33

credits for common core requirements[†] in traditional programs have on average 9%, and up to 16% more credits than in online programs. On the contrary, online majors have on average 18% (and up to 24%) more health informatics credits than in traditional programs. Together with credits for other medical and health sciences, online programs have on average 22.5% more professional credits, which is expected as online degrees tend to focus more on particular profession(s).

Looking only at the engineering-oriented courses (in computer science and engineering category), we observe that these courses constitute about 10% of total credits, or roughly 3-4 courses total, barely corresponding to a minor program [‡]. Also, all of the existing health informatics majors are

[†]Typically specified by the degree granting units of each institution.

[‡]Minors on average correspond to five to seven courses in the United States.

offered by non-engineering schools, and the engineering-oriented courses may be focusing on theoretical components of programming, and thus lacking typical hands-on laboratory components required by program certification bodies.

Moreover, a quick overview of the details of engineering-oriented course descriptions also show that majority of these courses are designed towards equipping students with basic programming skills. That is, there are no courses for helping students understand how complex informatics infrastructures work so that they can implement and/or support them during their careers. A particular emphasis can also be put on open-source tools and technologies, and how to work with them, as there exist many high-quality software developed and actively supported by open-source communities.[2,3,4]

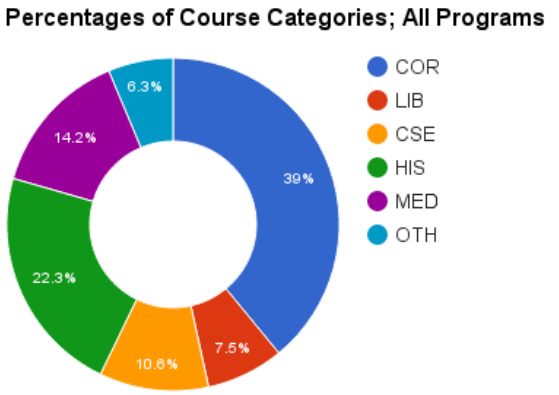

Figure 1: Categorical breakdown of course offerings in percentages, averaged over all programs in Tables 2 and 3.

4 The Need for Engineering-Oriented Health Informatics Programs

Based on our basic analysis of existing course offerings, we observe that there is an imminent need to teach students foundations of computer science and engineering to collect, analyze, store, visualize and interpret information. All these skills are important for students to understand the capabilities of informatics as it applies to particular problems in their own fields of study.

Students completing informatics majors should be able to understand the principles of computational sciences, and related engineering methods for core fields of study, such as networking, modeling, inference, visualization, data management, and decision-making and problem-solving. These skills also require a core set of fundamental engineering courses, which can mostly be offered by engineering schools.

In particular, we propose that students majoring in health informatics should be provided opportunities to:

- Have hands-on coding skills at the intermediate/advanced level,
- be aware of how to orchestrate data and computational infrastructures, and

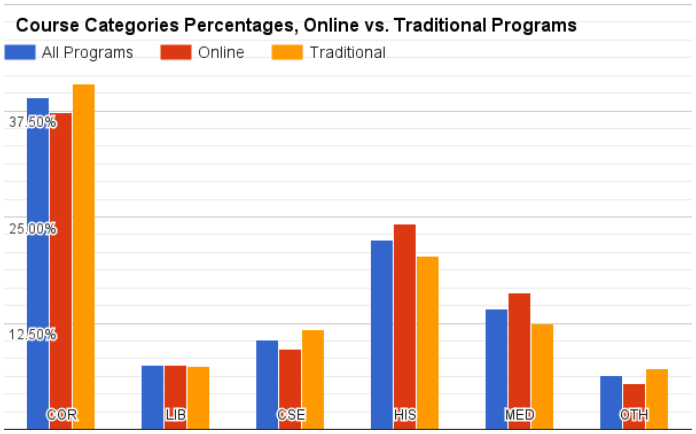

Figure 2: Categorical breakdown of course offerings in percentages. Averages of: all undergraduate programs (blue), online programs only (red), and traditional programs (yellow). Exact percentages are as follows:

	COR%	LIB%	CSE%	HIS%	MED%	OTH%
All Programs	39.04	7.53	10.60	22.27	14.23	6.32
Online	37.35	7.59	9.42	24.16	16.07	5.42
Traditional	40.73	7.47	11.79	20.38	12.39	7.23

- know about contemporary tools and methods analyze large datasets efficiently.

Our position and argument does not aim to underestimate the importance and necessity of existing health informatics courses offered by non-engineering schools. On the contrary, we advocate engineering-oriented health informatics degrees to *complement* existing professional skill-set in healthcare and medical sciences, to improve the strength and robustness of multidisciplinary teams in the field.

5 Summary and Future Work

We have looked at several different categories of courses in leading undergraduate-level health informatics major programs in the United States. We observe that engineering-oriented courses are on the low side, less than 10% on average, compared to other categories. Further analysis of the programs also show that none of these courses provide students skills to handle challenges of large datasets, information, and complex infrastructures that are quickly becoming common elements of contemporary IT architectures.

Our previous experience in implementing these complex infrastructures to handle data flow in public health clearly exhibits a skills gap in addressing the common challenges of routine tasks in implementation.[26] These challenges are typically handled inefficiently or left incomplete by existing multidisciplinary teams because of both (i) the skills gap, and (ii) the missing synergy within the team due to that same skills gap. Our proposed courses would help narrow that skills gap and increase synergistic activities within multidisciplinary teams in health informatics.

We look at a number of leading undergraduate-level health informatics majors, and we propose engineering-oriented health informatics degree programs focused in STEM education, that can (i) complement existing health informatics programs, and (ii) directly help narrow the skills gap in health informatics. In the future, we plan to continue analysis of both undergraduate and graduate programs in other informatics fields, especially in medical and healthcare, in more detail from an engineering perspective, and share results with the community.

References

1. D. Cenk Erdil. How much informatics is too much for public health big data? *Big Data and Analytics EdCon 2015*, August 2015, Puerto Rico.
2. The open medical record system. `https://openmrs.org`.
3. District health information system. `https://dhis2.org`.
4. C. Schmitz. Limesurvey: An open-source survey tool. *LimeSurvey Project, Hamburg, Germany*, 2015. `https://www.limesurvey.org/`.
5. Lincoln D. Stein, Bartha M. Knoppers, Peter Campbell, Gad Getz, and Jan O. Korbel. Data analysis: Create a cloud commons. *Nature*, (523):149–151, 2015. doi: 10.1038/523149a.
6. Muin J. Khoury and John P.A. Ioannidis. Big data meets public health. *Science*, 346(6213):1054–1055, 2014. doi: 10.1126/science.aaa2709.
7. J. Kim. Energy-efficient dynamic packet downloading for medical iot platforms. *IEEE Transactions on Industrial Informatics*, 11(6):1653–1659, 2015. doi: 10.1109/TII.2015.2434773.
8. B. Xu, L.D. Xu, H. Cai, C. Xie, J. Hu, and F. Bu. Ubiquitous data accessing method in iot-based information system for emergency medical services. *IEEE Transactions on Industrial Informatics*, 10(2):1578–1586, 2014. doi: 10.1109/TII.2014.2306382.
9. Cs10k initiative, national science foundation and american institutes for research. `https://cs10kcommunity.org/about`.
10. Racket: A programmable programming language, fund for the improvement of postsecondary education (fipse). `https://racket-lang.org/`.
11. Code.org, a nonprofit dedicated to expanding access to computer science. `https://code.org`.
12. Scratch - imagine, program, share. `https://scratch.mit.edu`.
13. Mit app inventor 2. `https://appinventor.mit.edu`.
14. St. john's university, bachelor of science in healthcare informatics. `http://www.stjohns.edu/academics/schools-and-colleges/college-professional-studies/programs-and-majors/healthcare-informatics-bachelor-science/`. Accessed: 2015-08-01.
15. Simmons college, bachelor of science in health informatics. `http://www.simmons.edu/academics/undergraduate-programs/health-informatics`. Accessed: 2015-08-01.
16. George mason university, bachelor of science in health administration. `http://catalog.gmu.edu/preview_program.php?catoid=27&poid=25283`. Accessed: 2015-08-01.
17. Eastern washington university, bachelor of science in health informatics technology. `http://www.ewu.edu/cbpa/programs/health-informatics-technology`. Accessed: 2015-08-01.

18. University of washington, bachelor of science in health informatics and health information management (evening degree). http://sph.washington.edu/prospective/programDetail.asp?progID=ugrad-bs-hihim. Accessed: 2015-08-01.

19. Georgia state university, professional bachelor of information sciences in health informatics. http://healthprofessions.gsu.edu/983.html.

20. University of illinois at chicago, bachelor of science in health information management. http://healthinformatics.uic.edu/health-information-management-degrees/.

21. Montana tech, bachelor of science in healthcare informatics. http://www.mtech.edu/academics/clsps/hci.

22. Western governors university, bachelor of science in health informatics. http://www.wgu.edu/online_health_professions_degrees/health_informatics_degree.

23. University of cincinnati, bachelor of science in health information management. http://himonline.uc.edu/health-information-management.

24. City university of new york (cuny), bachelor of science in health informatics management. https://sps.cuny.edu/academics/undergraduate/bachelor-science-health-information-management-bs.

25. Oregon tech, bachelor of science in health informatics. http://www.oit.edu/academics/degrees/health-informatics.

26. D. Cenk Erdil. Collecting public health data at a global scale. *DataCloud 2015 Workshop at Supercomputing Conference (SC15)*, November 2015, Austin, TX.