Design and Development of Hands-on EHR Usability Analysis through Open Source Tools and Free Resources

Hossain Shahriar
hshahria@kennesaw.edu

Chi Zhang
chizhang@kennesaw.edu

Department of Information Technology
Kennesaw State University
Marietta, GA 30060, USA

Abstract

In this paper, we introduce the redevelopment of Electronic Health Record Systems and Applications course for health information technology students. We make use of open-source tools and platforms in the hands-on projects to help students understand the topics through learning by doing. The course redevelopment details are presented, students’ perceptions of the course materials and future plan are discussed.

Keywords: Health Information Technology, Electronic Health Records, Usability, Open Source Tool.

1. INTRODUCTION

The Graduate Health IT Certificate Program at Kennesaw State University requires four courses, one of which is Electronic Health Records (EHR) Systems and Applications. When the course was first designed, it focused on the concepts of electronic health records, health data standards, medical billing and coding, and demonstration and hands-on practice of an EHR system for physician’s office (Gartee, 2012). Functionality of hospital EHRs are introduced using AHIMA’s Virtual Lab (VLAB) (AHIMA - America Health Information Management Association, 2019). Meaningful use (The Office of the National Coordinator for Health Information Technology (ONC), 2019) of EHRs and related regulations are presented as well. After completing the course, students are able to get familiar with the medical terms, workflow of patient care, features and system design of different EHR systems, as well as the privacy and security consideration for the EHR systems.

As Information Technology is advancing fast, technologies such as mobile health apps, wearable health devices, healthcare IoT, interoperability, and data analytics in healthcare are transforming EHRs from simply documenting clinical care to be central for patient care (Penn Medicine News, 2018). Additionally, while students enjoy learning the new concepts through guided hands-on exercises of practicing with the demo EHR systems, they are also interested in the system administration side of EHR systems besides the user and super user sides.

As a result, we redesigned the course to include more tools and platforms related to EHR and health app development including an open-source EHR system – Open EMR (OpenEMR, 2019). This
The paper introduces the tools and platforms and how the course activities make use of them.

The paper is organized as follows. Section 2 describes the EHR course redesign specifics including the tools, platforms, and the redesigned hands-on projects. Section 3 discusses the student surveys, their perceptions of the redesigned course. Section 4 presents our conclusion and future plan.

2. COURSE REDESIGN

Need for New Content
Funded by the Office of the National Coordinator for Health Information Technology (ONC), the Health Information Technology Workforce Components include an updated and expanded set of health IT instructional materials to help healthcare professionals and others who are interested in Health IT stay current with the current landscape of healthcare and health informatics, policies and regulations, and effective and efficient healthcare delivery best practices (Office of National Coordinator for Health Information Technology (ONC), 2012).

The new instructional materials are in five areas covering improved care delivery: population health, care coordination and interoperable health IT systems, value-based care, healthcare data analytics and patient-centered care.

These areas reflect the changes in the U.S. healthcare system spurred by healthcare reform to achieve better care, smarter spending and healthier people. The Health Management Information System module provides an overview of Electronic Health Records (EHR), Clinical Decision System, Medical Imaging System, Administration, Billing and Financial system, among other topics. Over the last decade many EHR systems are made open source, but few are compatible with ONC guidelines and meeting the standards for safety, security and privacy (e.g., OpenEMR, 2019).

The Installation and maintenance of Health IT Systems reflected the software development life cycle for EHR systems. However, it did not consider some important aspects for HIT professionals such as usability of EHR system. For example, configuring EHR modules using VistA EMR system (WorldVistA, 2019) does not focus on reduction of errors in entering data, making decision, and safety features of EHR systems. Based on these findings, we developed two new modules into an existing EHR to allow students developing the skills and examining the EHR systems in terms of usability and safety assessment, and other modules as discussed below.

Open Source EHR Resources
We introduce two open source EHR systems: OpenEMR (OpenEMR, 2017) and OpenMRS (Fazen et al., 2013) in the new course materials. Both of the EHR systems are open source and available to the public for installation. For both systems, our common module learning objectives include the following:

• Install and configure EHR application
• Create users, sites, patients, visits within EHR applications

Learning resources include slides, videos on accessing and using OpenEMR such as adding a new patient (OpenEMR, 2017) and documenting a visit (ZH Healthcare, 2011). The hands-on lab asked students to install and configure an OpenEMR application into XAMPP (Apache+MySQL) server. Students are instructed to configure the initial user account as administrator, setting up database name and password (see Figure1 as an example step) including installing any patches available based on the version under installation.

Figure 1: OpenEMR Installation and Configuration

Students then add a new patient information by filling various PHI information (e.g., Name, DOB). Figure 2 shows a snapshot of patient data addition. Next, students learn how to create a visit and provide information.
Similarly, students learn how to install and configure OpenMRS system and create patient profile, visit information, as ways of introducing the EHR application usage.

Table 1: Example of Feature Listing for EHR System

<table>
<thead>
<tr>
<th>No</th>
<th>Feature</th>
<th>Present (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Patients seen in the past year</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>List of previous labs for a given patient</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>List of allergies for a given patient</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>Summary Coversheet (similar to what VistA offers)</td>
<td>?</td>
</tr>
<tr>
<td>5</td>
<td>Notification or reminder</td>
<td>?</td>
</tr>
<tr>
<td>6</td>
<td>Billing based on provided service</td>
<td>?</td>
</tr>
<tr>
<td>7</td>
<td>Common coding scheme for diagnosis (e.g. SNOMED, ICD-10)</td>
<td>?</td>
</tr>
</tbody>
</table>

Open Source EHR Usability Analysis

The goal of this module (i) explain the design principles for EHR applications; (ii) analyze Opensource EHR applications for compliance with common and safety design principles. Students are provided learning resources on EHR usability criteria and then reuse the installed the EHR systems from prior modules to compare usability features.

Usability analysis focuses on user interfaces and if they followed established human interface design principles to interact with key users.
(doctors, patients) the way they are supposed think and work.

The American Medical Informatics Association Task Force on Usability has laid out 14 usability principles for the design of electronic medical records as part of its report on enhancing patient safety by improving usability of EHR systems in the Journal of the American Medical Informatics Association (Middleton et al., 2013).

The principles include:

1. Consistency — Design consistency and standards utilization
2. Visibility — System state visibility
3. Match — System and world match
4. Minimalism — Minimalist design
5. Memory — Memory load minimization
6. Feedback — Informative feedback
7. Flexibility — Flexible and customizable system
8. Message — Useful error messages
9. Error — Use error prevention
10. Closure — Clear closure
11. Reversibility — Reversible actions
12. Language — User language utilization
13. Control — User control
14. Documentation — Help and documentation

Students are asked to compare general design principles of usability between OpenEMR and OpenMRS. Table 2 shows examples of design features for comparison. Similarly, we also ask students to compare safety features of the two EHR systems.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Example of feature(s) observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency and standard</td>
<td>Color</td>
</tr>
<tr>
<td></td>
<td>Layout</td>
</tr>
<tr>
<td></td>
<td>Font, capitalization</td>
</tr>
<tr>
<td>Visibility</td>
<td>Display loading, search</td>
</tr>
<tr>
<td></td>
<td>Visibility of links</td>
</tr>
<tr>
<td></td>
<td>Visibility of navigation</td>
</tr>
<tr>
<td></td>
<td>Visibility regarding page and content layout</td>
</tr>
<tr>
<td></td>
<td>Important things visible for decision making?</td>
</tr>
<tr>
<td>Match</td>
<td>Primary menu on the left</td>
</tr>
<tr>
<td></td>
<td>Display of units accurately</td>
</tr>
<tr>
<td>Minimalist design</td>
<td>Showing of dates and times for sensitive information</td>
</tr>
<tr>
<td></td>
<td>Alerts show criticality</td>
</tr>
<tr>
<td></td>
<td>Display of height and weight on the same chart</td>
</tr>
<tr>
<td></td>
<td>Use moderate white space</td>
</tr>
<tr>
<td></td>
<td>Partition long data items</td>
</tr>
<tr>
<td>Minimize memory load</td>
<td>concrete examples (DD/MM/YY, e.g., 10/20/99)</td>
</tr>
<tr>
<td></td>
<td>Spell out abbreviations</td>
</tr>
<tr>
<td></td>
<td>Do not use color alone to convey information</td>
</tr>
<tr>
<td></td>
<td>Provide feedback on user’s location</td>
</tr>
<tr>
<td></td>
<td>Label units of measurement</td>
</tr>
</tbody>
</table>

Table 2: Comparing General Design Feature

<table>
<thead>
<tr>
<th>Criteria</th>
<th>OpenEMR</th>
<th>OpenMRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space provided between drug name, dosage, strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alert message shows the priority or criticality of the alert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display result information in columns wide enough to see full value and abnormality without adjusting scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics shows the reference range(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerical data are shown properly (e.g., no trailing zero)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E.g., Medication names are not unnecessarily truncated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: EHR design principles for patient safety
3. STUDENT FEEDBACK

To assess the effectiveness of the redesigned course materials and hands-on exercises, we conducted two surveys before and after the course materials are delivered. The key question driving the survey were: What was students’ knowledge level of the specified technologies? Did the redesigned materials help students learn about the topics/technologies? How much did each new exercise help?

The survey was created on the University’s Qualtrics system. Students were given the link and completed the survey online. 12 questions including four questions on students’ learning styles are included in the pre-survey.

1. Have you ever installed and configured Open Source Electronic Health Record Systems (e.g., OpenEMR)?
2. Have you been exposed to clinical terms or coding systems (e.g., SNOMED CT, ICD-10)?
3. Are you aware of EHR interoperability and using APIs for accessing EHR data?
4. Have you assessed the usability of EHR applications?
5. Have you designed and developed EHR applications using frameworks (e.g., Opal)?
6. Have you designed and developed mobile health applications using online tools (e.g., App Inventor)?
7. Have you assessed EHR for compliance with regulatory requirements (e.g., ONC Meaningful Use, and HIPAA regulations)?
8. Have you assessed security vulnerabilities in EHR implementation with analysis tools (e.g., RIPS)?
9. I learn better by doing hands-on lab work.
10. I learn better by listening to or watching online lectures.
11. I learn better by working through given examples.
12. I learn better by reading the material on my own.

The post-survey includes 12 questions with reference to the redesigned course materials. An open-end question is included in the post-survey as well for student comments and suggestions.

1. I am able to install, configure and apply EHR software (e.g., VistA, OpenEMR, OpenMRS).
2. I am proficient with the coding systems used in EHR including SNOMED and ICD-10.
3. I am now able to store and access data using APIs supporting EHR interoperability.
4. I am proficient with assessing usability of EHR applications.
5. I am able to design and implement EHR applications using Python framework (e.g., Opal).
6. I am able to design and implement mobile EHR applications using App inventor.
7. I am able to assess usability of popular mobile health apps.
8. I am familiar with the ONC test suites and HIPAA criteria for EHR application compliance.
9. I am able to work with static source code analysis tool (RIPS) to identify security flaws related to compliance criteria.
10. The hands-on labs and assignments helped me gain in-depth experience in design and develop open source EHR applications.
11. The hands-on labs help me gain authentic learning and working experience on EHR and Health Information Security and Privacy.
12. The course materials will help me apply the skills learned to my job or work for improved healthcare practice.

The open-ended question at the end of survey asks students to provide comments on the resources provided in the course and suggestions for improvement.

Pre- and Post-Survey Results

The sample size of the survey was too small to increase the confidence in the statistical significance of the findings. The reporting for the quantitative result is limited to descriptive.

The pre-survey shows that none of the 9 students who completed the survey were familiar with any of the topics introduced in the course: medical coding systems, usability of EHRs, tools or development of health applications, assessment of EHR regulation compliance and EHR security vulnerability. One student out of 9 knows about EHR interoperability and open-source EHRs as asked in the remaining two questions.

The post-survey result is encouraging. 13 students completed the survey and reported that they liked “learning by doing” – the hands-on labs helped them learn the topics introduced in the course, specifically the assessment of usability of popular mobile health apps. Students also reported that the installation and configuration of open-source EHR system was the most challenging activity and they encountered a number of errors that they were not able to fix without instructor’s help. It was especially difficult for online students. We plan to finetune the hands-on cases by proving more detailed instructions (and videos for online students) along with FAQs. Students also suggested it would be helpful to have an EHR system administrator, HIPAA representative, or someone
who works in the area as a visiting speaker to explain to the class the pros and cons of real-time systems and what skills required to seek jobs in health security for reality check and students to get more exposure.

5. CONCLUSIONS

This paper introduces the considerations and redesign of a course about Electronic Health Record Systems for health information technology students. The new instructional materials are in five areas relevant to improved care delivery – population health, care coordination and interoperable health IT systems, value-based care, healthcare data analytics, and patient-centered care. We designed hands-on exercises using open-source tools and platforms for introducing design and development of EHR systems, and assessment of EHR usability analysis as well as security vulnerabilities in EHR implementation. Taking students’ input into consideration, the future course development plan will include more open-source system instructions and guest speakers in HIPAA implementation and assessment.

6. ACKNOWLEDGEMENT

Our thanks to Affordable Learning Georgia Textbook Transformation Grants (M43, M87) of University System of Georgia for supporting us to redevelop the course materials.

7. REFERENCES


Computerized-Medical-Records-2nd-Edition/9780132499767.html


OpenEMR. (2017). Adding a New Patient - OpenEMR. Retrieved from https://www.youtube.com/watch?v=q_yXYg_g7EdE#action=share


