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

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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

ISSN: 2473-3857
v5 n4967

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.

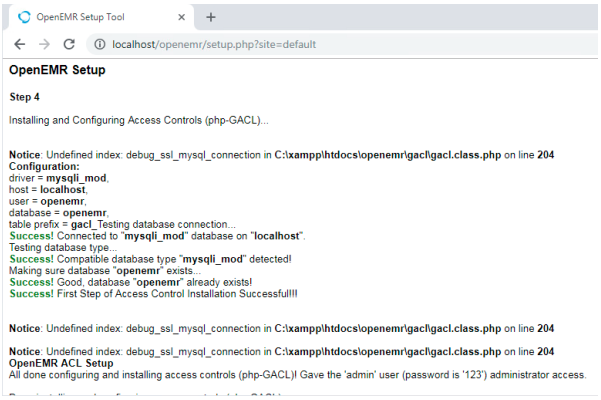

Figure 1: OpenEMR Installation and Configuration

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.

ISSN: 2473-3857
v5 n4967

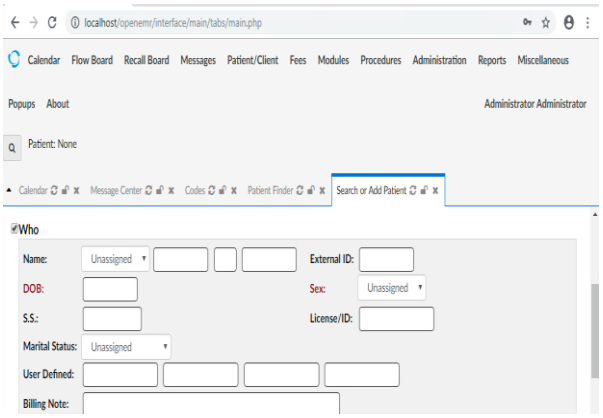

Figure 2: OpenEMR Patient Profile Addition

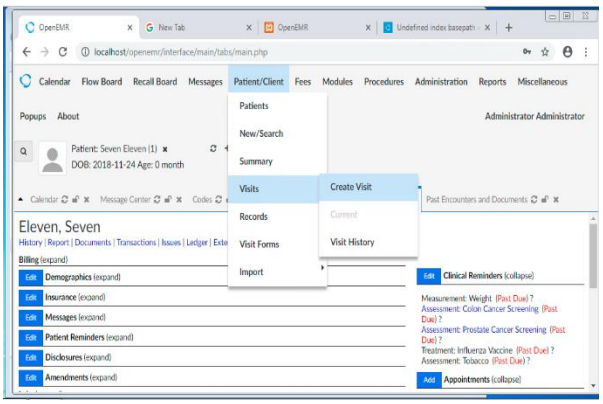

Figure 3: OpenEMR Patient Visit Data Addition

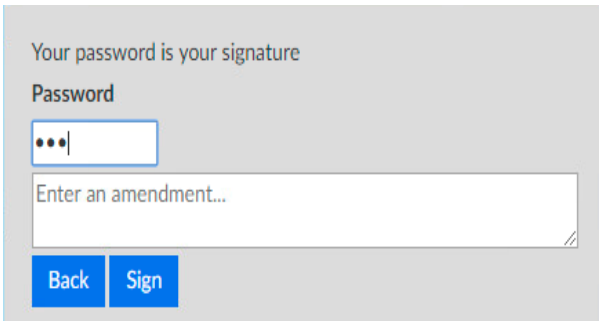

Figure 4: OpenEMR Patient Visit Data Saving

Similarly, students learn how to install and configure OpenMRS system and create patient profile, visit information, as ways of introducing the EHR application usage.

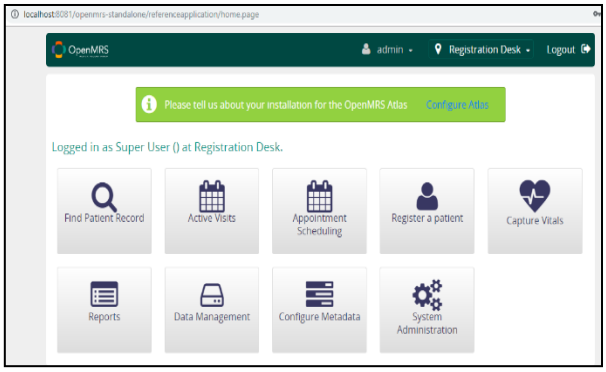

Figure 5: OpenMRS After Login

The activities also encourage students to look for useful features for medical clinics and hospitals when interacting with patients. These may include list of previous labs, summary of coversheet, notification reminder, billing, and common coding scheme. Table 1 shows an example of activity where students are asked to answer yes/no based on their interaction with EHR.

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

Table 1: Example of Feature Listing for EHR System

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.

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

Table 2: Comparing General Design Feature

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

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

AHIMA - America Health Information Management Association. (2019). AHIMA Virtual Lab. Retrieved June 12, 2019, from https://www.ahima.org/education/vlab

Fazen, L. E., Chemwolo, B. T., Songok, J. J., Ruhl, L. J., Kipkoech, C., Green, J. M., … Christoffersen-Deb, A. (2013). AccessMRS: Integrating OpenMRS with smart forms on Android. *Studies in Health Technology and Informatics*, *192*, 866–870.

Gartee, R. (2012). Electronic Health Records: Understanding and Using Computerized Medical Records. Retrieved June 12, 2019, from https://www.pearson.com/us/higher-education/product/Gartee-Electronic-Health-Records-Understanding-and-Using-Computerized-Medical-Records-2nd-Edition/9780132499767.html

Middleton, B., Bloomrosen, M., Dente, M. A., Hashmat, B., Koppel, R., Overhage, J. M., … Zhang, J. (2013). Enhancing patient safety and quality of care by improving the usability of electronic health record systems: Recommendations from AMIA. *Journal of the American Medical Informatics Association: JAMIA*, *20*(e1), e2–e8. https://doi.org/10.1136/amiajnl-2012-001458

Office of National Coordinator for Health Information Technology (ONC). (2012). ONC HIT Curriculum Overview. Retrieved June 25, 2014, from http://knowledge.amia.org/onc-ntdc

OpenEMR. (2017). *Adding a New Patient - OpenEMR*. Retrieved from https://www.youtube.com/watch?v=q_yXYgg7EdE#action=share

OpenEMR. (2019). OpenEMR. Retrieved June 12, 2019, from https://www.open-emr.org/

Penn Medicine News. (2018). Penn Medicine Launches Initiative to Transform Electronic Health Record Systems – PR News. Retrieved June 12, 2019, from https://www.pennmedicine.org/news/news-releases/2018/october/penn-medicine-launches-initiative-to-transform-electronic-health-record-systems

The Office of the National Coordinator for Health Information Technology (ONC). (2019). Meaningful Use | HealthIT.gov. Retrieved June 12, 2019, from Meaningful Use and the Shift to the Merit-based Incentive Payment System website: https://www.healthit.gov/topic/meaningful-use-and-macra/meaningful-use

WorldVistA. (2019). About VistA — Welcome to the WorldVistA homepage. Retrieved June 16, 2019, from http://worldvista.org/AboutVistA

ZH Healthcare. (2011). *Openemr Tutorial - 5A - New Encounter & Coding -ZH Healthcare*. Retrieved from https://www.youtube.com/watch?v=5Eo1q1mPM5M#action=share