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Abstract

Students in a health informatics program benefit from hands-on experience with an electronic health record (EHR). This case study reviews and explains a process of bringing the EHR and relevant patient records to students in a classroom or instructional setting at a university. We analyze and evaluate multiple options for EHR systems in an instructional setting. Following the unsuccessful implementation of one EHR system that required substantial use of programming languages to interface with the database to migrate data, we decided to take a different approach and implement a different EHR system. This article primarily describes the selection and implementation process after the restart from an educational perspective. A rubric was employed to assess EHR systems for educational purposes. Following the selection of one EHR system, elaborate mock patient scenarios were developed by a physician after which the simulated EHR data was manually entered.

Keywords: Electronic health record system, implementation, health informatics program

1. Introduction

Electronic health records (EHRs) hold the promise of revolutionizing healthcare. In 2009, the HITECH Act ushered in a major spike in the adoption of EHRs in healthcare organizations in the United States through incentive programs. In anticipation of continuing growth in the healthcare industry, universities embarked on the preparation of students for the health information technology (HIT) workforce. A growing number of HIT professionals now support healthcare practice. Burning Glass, a labor market analytics firm, found that job announcements in health informatics increased by 37% between 2007 and 2011. One common and prevalent HIT is the electronic health record (EHR). The EHR "is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting" (HIMSS, 2017). By design, it generates a complete record of the patient encounter and supports clinical decision-making. The electronic nature of the record streamlines the clinician's workflow and has the potential to improve quality of care and patient outcomes (HIMSS, 2017). Knowledge about the EHR and related technologies is essential for the HIT workforce as well as healthcare professionals.

Healthcare professionals are not always prepared to use the EHR optimally to realize the efficiencies and improvements in patient outcomes. Undergraduate medical students, in particular, have limited exposure to EHR training as part of their education (Borycki et al., 2009b; Borycki, Joe, Armstrong, Bellwood, & Campbell, 2011; Otto & Kushniruk, 2009), distancing them from the situational perspective of "real world" clinical practice. In a recent observation of clinical examination, Biagioli and colleagues' findings indicated that while clerkship students performed well in EHR-related communication tasks, their EHR skills were deficient in EHR data management including medical history review, medication reconciliation, and allergy reconciliation (Biagioli et al., 2017). Several others have called for hands-on EHR practice in medical education for documentation, specifically with an emphasis on balancing EHR documentation with patient engagement, practicing order entry in the EHR and utilizing decision aids that accompany EHRs (Atwater et al., 2016; Hammoud et al., 2012; Wald, George, Reis, & Taylor, 2014). Despite the transforming nature of the EHR in healthcare, its impact on patient care, and the numerous calls to adopt the EHR in medical education, EHRs have yet to be routinely integrated into medical curricula to teach optimal use to medical students (Kushniruk et al., 2012b; Milano, Hardman, Plesiu, Rdesinski, & Biagioli, 2014). More should be done to prepare individuals before they enter healthcare practice or the healthcare industry.

It is important for universities to offer programs designed to improve students' learning to not only better their job prospects but also to realize improvements in healthcare with well-prepared professionals. However, at universities, the actual integration of EHRs into educational programs has been challenging to achieve. According to Herbert and Connors (2016), although 49% of faculty in undergraduate nursing programs surveyed was aware of EHRs for academic use, 9% had decided to use them on a small scale, and only 9% fully utilized them. Nursing programs find it challenging to bring such HIT into their classes due to technical, financial and knowledge limitations (Kushniruk, Kuo, Parapini, & Borycki, 2014b). For universities wanting to integrate EHRs into educational programs, in this paper, we illustrate EHR system implementation to pave the way for other programs to implement these technologies.

In general, the university-based programs range from those in health informatics, medical informatics to nursing informatics. The National Library of Medicine defines health informatics as "the interdisciplinary study of the design, development, adoption, and application of IT-based innovations in healthcare services delivery, management, and planning" (HIMSS, 2014).

Conceptually, health informatics is broader than medical informatics which is more focused on applications in medicine; however, these terms are often used interchangeably. Additional terminology adds to the confusion in understanding health informatics. When the discipline is clinically focused, depending on the targeted audience, it is commonly referred to as clinical informatics or nursing informatics. It must be noted that in addition to university-based certifications and baccalaureate and master's programs, the professional associations offer certifications. In university-based health or medical informatics education, too, an applied rather than a foundational focus has been deemed appropriate lately. However, in offering such health, medical or even nursing informatics education, the integration of HIT presents a challenge. In an applied focus, the opportunity to learn about HIT through hands-on exposure is critical. Experience with EHR systems especially is imperative as these systems are central to healthcare today.

In our department, our interest is in teaching health informatics with an emphasis on information systems (IS) while addressing the educational needs of nursing and allied health students. Few models of successful EHR use exist in health

or medical informatics education or in nursing, allied health and medical education. Discussions of EHR use in health informatics education particularly from an information systems or computer science standpoint are almost non-existent.

The field of health informatics is moving beyond EHR implementation and toward optimizing systems for better patient care, improved patient engagement and robust data analytics to inform practice efficiencies. However, the initial adoption and basic application of the system remain important because these stages provide the foundation for students to develop a deeper understanding of the system. For instance, without understanding how the components of the EHR are integrated and work together to support continuity of care, how the EHR functions, and the significance of decision-making tools in the EHR, it is difficult for a student to start thinking about innovative solutions to problems in everyday practice. Given the calls for EHR training in curricula and the significance of situational learning, we implemented an EHR system in our health informatics program to integrate practical experiences into our classes.

In this paper, we describe our experiences in bringing the EHR system into our classes with limited technical and financial resources to expend on such an endeavor. A few years ago, after the unsuccessful implementation of an EHR system that required use of programming languages to interface with the database to migrate data, we reconvened to assess alternative solutions. While it would have been possible to enter data in the previous EHR system, we found this to be challenging in the face of inadequate training and manuals and lack of clinical data. In this paper, we concentrate on our efforts and discussions after the restart. We describe the evaluation and selection processes and the challenges we faced in reaching a consensus. We demonstrate the use of a rubric to assess multiple EHR systems in the market with the intent of integrating the EHR into the curriculum. Then, we describe the implementation phase during which we populated the EHR with simulated data through our collaboration with a physician. Lastly, in the post-implementation phase, we present the ways in which we have integrated or plan to integrate the EHR in our classes.

2. EHR in Education

Depending on the department where health informatics or medical informatics is housed, the emphasis can be on computer science, information systems, nursing or medicine. A robust deployment of the EHR in education comes from the interdisciplinary faculty in the School of Health Information Science at the University of Victoria. The University of Victoria's web-based portal allows students to access multiple open source EHRs for a simulated healthcare information system experience representative of the real world in health informatics education as well as in nursing, allied health and medical education (Borycki et al., 2009b). With the objective of giving students hands-on experience with an EHR, technological aspects of system use are emphasized for health informatics students whereas methods such as problem-based learning are applied in integrating the EHR for health professions students (Kushniruk et al., 2014a). Below, we describe how the EHR portal is integrated in health informatics education, as well as in nursing and medical education.

In the University of Victoria's model, "Teaching essential concepts related to health information technology involves having students access different types of health information systems and applications in terms of identifying system features, optimal user interface designs, product advantages, and system limitations as well as potential user problems" (Kushniruk, Borycki, Armstrong, & Kuo, 2012a, p. 92). For example, health informatics students evaluate EHRs employing methods from usability engineering, such as heuristic inspection, cognitive walkthrough as well as usability testing. When conducting usability testing, students observe subjects who interact with the EHR system to work with simulated patient data (Kushniruk et al., 2012a). Additionally, open source EHRs (such as Open VistA) that the university deploys allow students the opportunity to explore EHRs and programming in detail, and to design and develop new working EHR modules that can be interfaced with existing EHRs (Kushniruk et al., 2012a). According to Borycki and colleagues, hands-on experience with EHRs improved undergraduate health informatics students' competencies (Borycki, Griffith, Reid, Kushniruk, & Kuo, 2013), which supports the premise that hands-on exposure is critical in HIT education.

At the University of Victoria, nursing students have a different approach to learning about EHRs using the same EHR portal. These students are asked to discuss what works and what does not work well when using EHRs in nursing care, and they are trained in documenting care using EHRs (Borycki et al., 2009b). Also at the University of Victoria, to integrate EHRs into undergraduate medical education, a problem-based learning approach is applied. An office-based EHR system designed for private medical practice (by Anthologix©) was modified for use in the

medical program. Medical students across geographically dispersed sites could work on the patient "case of the week" via the EHR. The objective was to teach fourth-year medical students about key aspects of the EHR embedded in problem-based medical education. According to Kushniruk and colleagues, "Rather than obtaining course material from paper-based handouts (e.g., about Tom's evolving condition), as had been previously done, students interacted directly with an EMR during the pilot study to (1) access basic patient information, (2) explore features such as decision support, and (3) record data and medication information using the EMR" (Kushniruk et al., 2012b, p. 25). Findings from an evaluation of the teaching approach indicated that the EHR can be successfully integrated into problem-based medical education.

In some clinical environments such as emergency medicine, it is ideal for students to practice with real EHRs (Wittels, Wallenstein, Patwari, & Patel, 2017), but this is not always possible due to policies and regulations such as HIPAA in place. Hence, many medical students do not have access to EHRs in the clinical environment. Biagioli et al. (2017) recommend simulated EHR training as the solution. The aforementioned interdisciplinary faculty at the University of Victoria reported using simulated EHR data in their problem-based learning approach in medication education (Kushniruk et al., 2012b). Milano and colleagues at Oregon Health & Science University (OHSU) also describe deploying simulated EHR training to demonstrate "how a well-organized chart helps ensure safe, efficient, and quality patient care" (Milano et al., 2014, p. 399). As part of their family medicine clerkship at OHSU, third-year students used an EHR platform to "review and correct a simulated medical chart for a complex virtual patient with chronic diseases and years of fragmented care" (Milano et al., 2014, p. 399). Students "write orders and prescriptions, create an evidence-based plan of care for indicated disease prevention and management, and review their work in a small-group setting" (Milano et al., 2014, p. 399). Milano and colleagues do not yet offer evidence of the effectiveness of such integration in teaching medical care. However, they believe that simulated EHR training "is an effective, interactive method for providing learners with EHR skills education" (Milano et al., 2014, p. 399).

As noted previously, descriptions of EHR use in health informatics programs within computer science or information systems departments are scant. A common approach is to allow students to gain exposure to EHR systems through practicums or internships in healthcare settings (Wilson & Tulu, 2010). One health informatics program in the School of Computing and Software Engineering at Southern Polytechnic State University states that it includes hands-on exercises with EHR systems in its courses. They use a range of commercial EHR software CPSI, NeuMD, and eClinicalWorks (eCW), and a few open source software programs, such as OpenVistA by the Department of Veteran Affairs, OpenEMR, and AHIMA Virtual Labs (Zhang, Reichgelt, Rutherfoord, & Wang, 2014). However, they do not provide the details of implementation or a discussion of the actual integration in the classroom or instructional setting.

In a health informatics program such as ours that is housed in the information systems department which caters to students in health informatics as well as in nursing and allied health, several decisions must be made regarding open source versus commercial EHR and the amount of technical, financial and knowledge resources that can be expended. Although the University of Victoria's model is ideal for teaching EHR skills to health informatics students as well as health professions students, such an elaborate set up, which Borycki, Armstrong, and Kushniruk (2009a) describe in terms of the architectural framework and the evolution of the educational portal from prototype to production system, may not be feasible for every educational program. As such, in this case study, we offer our experiences in implementing an EHR system for educational purposes under the constraints of financial resources available and technical expertise of faculty who can be dedicated toward such an endeavor in an information systems department.

3. Methodology

Prior to EHR implementation, when thinking about how learning takes place, we considered situated learning. In applied courses, if students were to gain both the 'knowing what' and the 'knowing how,' we presumed that there should not be a separation between learning and doing. Drawing from situated learning, we assume that "knowledge is situated, being in part a product of the activity, context, and culture in which it is developed and used" (Brown, Collins, & Duguid, 1989, p. 32). In the implementation of the EHR, we aspire to bringing the activities, contexts, and cultures associated with the EHR to our classes.

After an initial and unsuccessful attempt at implementation of an EHR system that required substantial use of programming languages to interface with the database to migrate data while presenting challenges in manually entering data, we decided to take a different approach (Figure 1). For this case study, we describe the process after this restart, which covers the selection, implementation and post-implementation phases of adopting eClinicalWorks EHR. In the selection phase, we elaborate on discussions that ensued in the evaluation of EHR products. In the implementation phase, due to HIPAA regulations on real patient data, we chose to write elaborate mock patient scenarios and manually enter simulated data. We describe our collaboration with a physician from a hospital system in the community in an approach we deemed appropriate for creating simulated patient data and populating the database. Our experiences, including the challenges, inform the process of bringing the EHR, a record that is central to healthcare operations today, to students in the classroom or instructional setting at a university.

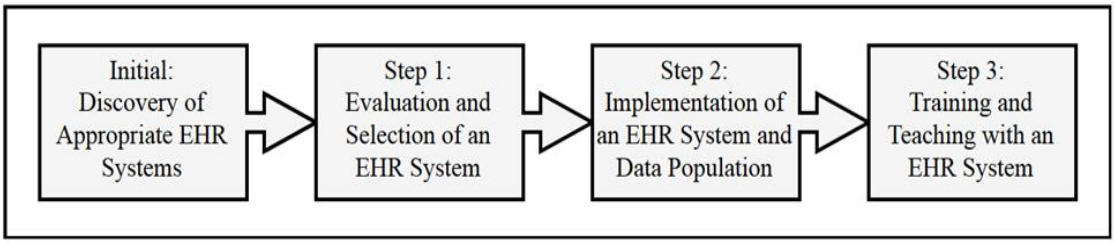

Figure 1: Steps in EHR Implementation

4. EHR Implementation

Background

At Northern Kentucky University (NKU), our interest is in applied health informatics as it is taught to prepare health IT managers and the HIT workforce. Our health informatics program—which offers the master's degree, the certificate and soon the bachelor's degree—is housed in the Business Informatics Department within the College of Informatics. As such, the program entails an information systems focus. The program works closely with the Nursing and the Allied Health Departments in the College of Health Professions. Radiologic science, respiratory care and health science constitute the Allied Health Department. Both departments offer bachelor's and master's degrees. Additionally, the Nursing Department offers the Doctor of Nursing Practice (DNP).

While housing health informatics in the Business Informatics department brings the benefits of an in-depth focus on information systems and information technology (IT), we have had to work hard toward leveraging the expertise available within the College of Informatics and the College of Health Professions. One example of striving to offer robust, HIT-based learning experiences is the college's desire to offer access to and use of an EHR system to its students.

EHR implementation and its basic application are central to healthcare and to health informatics education. Without an EHR system, students become limited in thinking about complex data, system integration, security and subsequent workflow redesign for optimal application to realize efficiencies in their future workplaces (Wagner, Lee, & Glaser, 2013). This paper relates our experience with the evaluation and selection phase and the implementation and post- implementation phases of the EHR in our health informatics program, so other IS departments that may be interested in health informatics can be aware of the options for providing hands-on training to students in HIT education (Hartley & Jones, 2012; HealthIT.gov, n.d.).

Step1: Evaluation and Selection

An EHR system was installed in the health informatics program approximately five years ago; however, we struggled to complete implementation due to issues in employing the resources required for substantial use of programming languages to interface with the database for the purpose of migrating data. The vendor does not offer clinical data migration services. Although manual entry of a small set of data was possible, the faculty found it

challenging to create a workflow in the system in the absence of adequate training and manuals and with the lack of clinical data. The situation led to attempting to use SQL to import data to populate the EHR system. However, the advantage of this EHR system, SabiaMed ClinNext, was the vendor's willingness to allow access to the backend. The preceding presented a complicated situation in that we do not have a medical school that is affiliated with a hospital where an EHR system would contain clinical data from actual patient records. Even if we did have a medical school, due to HIPAA regulations, students in our program would not have access to the EHR maintained by a university-affiliated hospital.

We started over by reviewing other options for an EHR system, including options for populating the database. Making the right choice that meets the needs of a healthcare organization or an educational program is an important part of the implementation process. To populate the database, we briefly considered de-identified data collected by the Cabinet for Health and Family Services (CHFS) in the state of Kentucky. This option offered us limited use because the de-identified data on each patient was minimal. The state records contain mainly diagnosis and procedural codes (ICD and CPT codes) and limited demographic information. As such, the records were not useful for populating an EHR due to the lack of core data elements of a patient record, for example, problem lists, medications, and history. Additionally, the state required that a process be in place for data use agreements, so guidelines specifying the applications in teaching and learning and the importance of confidentiality, even though the data was de-identified, were clear to the university and our students. As these hurdles seemed to be cumbersome for teaching purposes, we populated the database with test / simulated clinical data when we selected another EHR system.

To discover an EHR system suitable for our purposes, we reviewed vendors' products exhibited at the Healthcare Information and Management Systems Society (HIMSS) conference and rankings in KLAS Research which is a service that provides EHR vendor performance reports (Mooney & Boyle, 2011). Moving forward, we considered three EHR products. The first product, iCare Academic, came with test data for teaching purposes but required a monthly subscription fee. The second product we evaluated, eClinicalWorks, was a donation from the company and was far superior in functionality and had been implemented in several practices. However, it did not come with test clinical data. A healthcare professional suggested a third product, Practice Fusion. Practice Fusion is widely deployed in small to medium-sized practices and is available free of charge for physicians to deploy. Subsequently, we had demos for two products, iCare Academic and eClinicalWorks. There was no initiative for Practice Fusion; hence, there was no demo.

Following the demos, an in-depth discussion of all three products ensued. While features, functionality and usability of a system were deemed important, IS faculty were more interested in knowing about the capability of the system to import data. Below, we provide a synopsis of the most significant questions that arose during demos and ongoing discussions.

1. How is data imported into the system given that we have neither patients nor legacy systems? What are the options - import tool, HL7 messages, CCD (Continuity of Care Document), direct import using SQL, manual data entry?
2. Is there the capability to segregate patients for specific groups of users?
3. Is there the capability to create multiple practice locations? In our use case, a location would be analogous to a course. Are patients in different locations segregated for the users specific to that location?
4. Is there the capability to reset / refresh / restore the database at the end of the semester? Can this feature be location specific?
5. Are there instructions on creating new CDS rules (apart from customizing the stock list provided)?
6. What elements of CPOE are available - ordering labs, radiology, consults?

In essence, faculty had expectations for the EHR system that went far beyond developing assignments on EHR features, functionality, and usability. We were interested in importing a large data set, even though we did not yet have a plan for obtaining the data whether de-identified or simulated. A suggestion that was offered was to extrapolate data based on known parameters in a small clinical data set using an algorithm; however, no one followed up on the suggestion. We wanted to know if an import tool existed. If it did not exist, we wanted to know

if there was an API and whether or not we could share the documentation (ERD, data dictionary) regarding the tables / fields in the databases. The reasoning was that we can teach healthcare data analytics with a large healthcare data set. Downloading progress notes from the EHR for text mining and extracting data from the HER for analytics were expected for such a course. Other interests included using the EHR database schema and data in teaching relational database concepts, using the EHR for HL7 messaging exercises, and creating new CDS rules. Additionally, for a large student body enrolled in different courses with multiple sections, a system capability that allowed students to work in separate practice locations (analogous to separate work spaces in different courses) each with a set of patient cases that could be reset / refreshed at the end of the semester was considered essential.

It was clear, given our expectations for system capabilities, that an open source EHR, such as OpenEMR, would be the ideal choice. This choice, however, would put us back into the situation we were in previously when we tried to implement another product that required additional resources. (It must be noted that the previous EHR product, SabiaMed ClinNext, which charged an annual subscription fee was not open source.) In general, open source EHRs require substantial resources (technical expertise and medical knowledge) and time on the part of faculty who are dedicated toward its development and implementation. Hence, someone must be willing to be committed to the implementation of an open source EHR. In our discussions, it was unclear who would accept such a responsibility. Also, we were not certain about expending additional financial resources toward contracting outside technical and medical experts. We proceeded to select one product from the three we had considered. While the iCare product was designed for educational purposes, it involved a monthly subscription fee, which was discouraging. Practice Fusion which is completely free for physicians to use did not offer technical support. There was a concern that questions regarding the software may become difficult to resolve without technical support.

We had three follow-up phone meetings with eClinicalWorks to address our questions. By this time, we had started to focus on eClinicalWorks. We found that the vendor could provide neither the simulated data used in their demo nor the tools for data import and extraction if we were to obtain our own data. The vendor's response to our unique situation was that the data could be manually entered. According to the vendor, in a practice, the data migrated from legacy systems can usually be provided on templates, and the cost for such migration was a one-time charge of $3,000. The vendor's market was small to medium-sized practices and small hospitals. They offered the software as a donation but lacked experience in the use of such software in academic settings that emphasize information systems education.

To reach a consensus, we created an EHR evaluation rubric for selection in educational settings. A decision had to be made about one product. Table 1 illustrates one member's evaluation of all three EHR products.

Table 1 shows that eClinicalWorks was superior in functionality and standards compliance. The vendor promised timely and continuous updates and installations to ensure changing requirements in the healthcare industry. The product commanded a substantial market share and was easy to use. Additionally, the vendor provided excellent training, manuals and technical support which would allow us to integrate the EHR system into our classes quickly. A drawback was that the vendor did not offer products designed for educational purposes and was uninclined to share simulated data used in their demos.

The first product in Table 1, iCare Academic, was designed for educational purposes. Although the vendor had not yet signed with academic clients, the product was easy to use with good technical support from the vendor. The biggest advantage was that iCare Academic came with test patient data. The vendor, having designed the product for educational purposes, was not as focused on functionality and standards compliance which are normally required for competing in the healthcare market. The vendor's main market was and continues to be hospitals and practices to which they offer the original iCare product. There is, however, an important update since the time we attended the demo. The vendor has retired iCare Academic. Instead, the vendor has entered a partnership with Pearson which offers RealEHRPrep with iCare via its MyLab bundle. Educators can integrate MyLab into their courses directly after purchase from Pearson. Also, several nursing programs that have already entered a partnership with Pearson for administrative purposes (a new trend in university administration) are using RealEHRPrep with iCare bundled in MyLab. Pearson and iCare anticipate expansion into the health information management (HIM) market. The HIM programs differ from those in health informatics in that the former programs have a stronger emphasis on medical coding.

The third product in Table 1, Practice Fusion, had sufficient market penetration while being offered to physicians free of charge. However, technical support and training were almost nonexistent; thereby, Practice Fusion would require expertise in and comfort with both technical and medical aspects of EHR implementation. Data migration was possible with assistance from the company. The product was not designed for educational purposes. Also, in the healthcare market, it lagged behind commercial products in functionality, standards compliance, and ease of use.

EHR System Evaluation Rating Scale 1 = Poor; 2 = Fair; 3 = Good; 4 = Excellent							
Vendor	**Cost**	**Robust Functionality:** Includes practice management, insurance details, integration with workflows, decision support, patient portal, mobile support…	**Standards Compliance:** HL7, ICD-9/10… + Meaningful Use updates	**Longevity and Market Share** (Ensures updates)	**Designed for Educational Purposes:** Includes **simulated cases**…	Ease of Use + Availability of training, tech support, and documentation	Hosting
iCare Academic Score=13	**Initial Install:** $3,000 **Per Student:** $75/6 months; $125/12 months	2	2	1	4	4	Cloud Service Model
eCW Score=17	**Initial Install:** $750 per day **Data Support:** $750 per day	4	4	4	1	4	Client-Server Model (Cloud Service Model for extra charge)
Practice Fusion Score=12	Free	3	3	4	1	1	Cloud Service Model/ Client-Server Model

Table 1: EHR Evaluation Rubric

For students to gain a working knowledge of the system with hands-on exercises on full, robust functionality of the system, we decided to acquire eClinicalWorks which, according to one ranking at the time, was one of the top three products on the market. Epic and Allscripts were the top two products, followed by eClinicalWorks. Epic and Allscripts did not have special pricing for academic clients for instructional purposes. Moreover, eClinicalWorks offered excellent technical support—the importance of which is often underestimated. One of the main reasons, however, for our selection was the company's generous donation of the EHR system to the university for teaching purposes. A shortcoming of our decision was that it is proprietary software, and we did not have access to the backend.

Step 2: Implementation

After signing the contract with the company, we commenced installation. Although the product was donated for educational purposes, there was a relatively small charge ($750) for installation. We chose the client-server option over the cloud / SaaS option as the latter would have incurred a monthly charge for hosting the system on the company's cloud server. The client-server option allows us to host the system at the university and to do so without the additional cost. Prior to installation, our systems analyst prepared a list of questions which were addressed by the vendor during our follow-up phone meetings. Our systems analyst worked with the company's engineers to install the EHR software which took approximately 8 hours. The installation was facilitated via phone calls and remote connectivity to the server with no major issues.

In the interim, we worked with a family medicine physician from a hospital system in our community to obtain clinical data in the form of elaborate mock patient scenarios to populate the EHR system. The family medicine physician serves on the advisory board of our health informatics program. At a networking event, we communicated with the physician about the possibility of using simulated data to populate the EHR system, which led to our collaboration.

To start, the physician provided a few mock patient scenarios. This approach was deemed appropriate due to HIPAA regulations which do not allow unauthorized users access to real clinical data. The following are the components of our mock patient scenarios which comprise core clinical data elements: Chief Complaint, Medications, Medical History, Allergies, Surgical History, Family History, Social History, Vitals, History of Present Illness (HPI), Review of Systems (ROS), Physical exam, Tests (Labs / Radiology), Assessment, Treatment, Visit code, Follow-up, Computerized Physician Order Entry (CPOE), Problem list and Preventive Medicine (See Appendix 1.). We held an initial meeting to test our EHR system with one mock patient scenario to gauge feasibility of the approach.

As the process worked smoothly, the physician proceeded to provide 50 mock patient scenarios and several follow-up scenarios. A student in the Master of Health Informatics (MHI) program, who is the third author of this paper, entered these patient scenarios into the system because we would have had to, again, pay the vendor to import through the backend. We would have incurred this charge because data imports were not included in our contract. We started in the front office module and entered administrative data including demographics, insurance information and contact / next of kin. Then, we entered clinical data based on the mock patient scenarios the physician had provided and completed billing to close the loop. Hence, full patient encounters are documented in the EHR system from front office to billing.

Step 3: Post-Implementation Training and Teaching

The training phase of post-implementation is important as it informs all individuals who will be using the new EHR system and its functionalities. In a healthcare organization, it is critical to invest in training to ensure a smooth transition from paper to electronic patient records as well as to receive support and to lower anxieties among all who are involved in the process (HIMSS, n.d.). In an interview published under the title: *Tapping technology to its fullest potential* (2010), Mitchell states that training on benefits of the EHR system is as important as how-to skills in using the system and its capabilities. In our program, we use the system for teaching purposes, so we also participated in training to create the most effective and engaging assignments for students to work on in our classes.

To get its clients started, the company offers limited amounts of data import and set-up raining, including

billing set-up. To better acquaint ourselves with the EHR system, we had more in-depth, week-long training sessions designed for both system administrators and users. The training included the following segments: administrative set-up, front office, EMR, and billing. The vendor had offered free training for two NKU employees at their headquarters in Boston with the idea that the two employees would return and train others in an organization. We chose remote training instead and incurred a charge for it, which we deemed a suitable option for us as it allowed more people from the College of Informatics and the College of Health Professions to attend. There was also the option of bringing an eClinicalWorks trainer to campus which was relatively more expensive.

After the training, we developed assignments to give students hands-on experience with the EHR system. To start, we created an assignment for undergraduate students to go into the EHR system and look up information on a patient, including lab values and radiology images, and to assess features and functionalities of the EHR, including decision aids. As many of our students are online students, our systems analyst had made the EHR system available on a virtual machine for remote login. Another option was for students to do the assignment in our Health Informatics Lab as the client is installed on all of the lab's computers. Many College of Health Professions students took the latter option as, unlike IS students, it was easier for them to come to the Health Informatics Lab than to install VPN and VMWare to do the assignment remotely. The health informatics faculty is also available to assist if the students choose to visit faculty offices to do the assignment. With hands-on HIT assignments, adequate technical support is essential for students because some students find the technicalities of such an experience daunting.

A more in-depth integration of robust functionality afforded in the EHR system is in the works as we are designing an undergraduate course on healthcare information systems to be offered soon. The course will cover concepts and trends in the implementation of clinical information systems, and it will include several in-depth exercises in using the EHR system. Implementation of clinical information systems and redesigning workflows will be emphasized. Learning about the implementation of an EHR system can prepare students to implement other clinical information systems, for instance, a telemedicine system. We continue to use the donated software and work with the company which provides us maintenance, upgrades and troubleshooting, all free of charge for educational purposes.

5. Discussion

In this case study, we present our experience in implementing an EHR system for educational purposes. Although it may not be the best approach for all IS programs interested in adopting the EHR to train their students for job readiness skills in the HIT space, it does provide ideas for such implementation. More importantly, our experience should create an awareness of the obstacles we encountered and the decisions we have had to make to bring the EHR to the classroom. For instance, IS programs that are interested in the programming and database management aspects of the EHR system may decide to select a vendor that allows working with the backend or an open source EHR software that is available for download.

In working with open source EHR systems, students can extend existing open source EHRs as programming assignments by building new databases and interfaces. If the choice is to implement an open source EHR, the department must be prepared to have faculty who are willing to dedicate their technical expertise and time to the implementation. Collaborations with healthcare professionals, especially physicians, can inform the design and development of databases and interfaces. Such collaborations may require additional financial resources if experts are to be contracted. In our department, the physician who wrote the mock patient scenarios serves on our advisory board and did so as a service to the university. These collaborations with physicians can go beyond creating simulated data as we have done.

If the decision, however, is to implement a commercial EHR product, opportunities can be presented for health informatics students to learn about components of the EHR that support continuity of care, complexities of healthcare data, workflow redesign, and implementation of the EHR. Borycki and colleagues interviewed undergraduate health informatics students and found that there is a need to educate students about best practices in interface design, workflow, and implementation before delving into the design of EHR software (Borycki, Griffith, & Kushniruk, 2016). Furthermore, for health informatics students, there is a need to extend the integration of the EHR to include hands-on training in the interoperability of healthcare information systems. Open source EHRs,

however, are more suitable for teaching interoperability because commercial EHRs, although interoperable, possibly require the vendor's services in achieving interoperability. Regardless of whether the choice is open source, free, or commercial EHR, simulated patient data is likely easier and more feasible to create than acquiring de-identified patient data. The majority of healthcare organizations, including government entities, are reluctant to share patient data even if it is de-identified due to the small chance that such data can be linked back to its corresponding individual.

We have implemented a commercial EHR which does not allow us access to the backend. We met the expectations expressed by faculty in questions 2, 3, 4 and 6 listed in the evaluation and selection section of this paper. We have CPOE for ordering labs, radiology and consults. We can create multiple practice locations and segregate patients in different locations via controlling permissions. In other words, we are able to manage separate spaces for students in different courses with multiple sections to do their assignments with an assigned set of patient cases. We can rewrite the database with our back-up, so the students in a new semester can have data that is not compromised. The back-up, however, is not specific to separate spaces that are managed for students to work in different courses. That is, the process of using back-up rewrites the entire database. In meeting the remaining expectations expressed in questions 1 and 5 on the list, we failed. That is, we do not have a tool to import large data sets. We can manually enter a small data set. We are unable to create tools for importing or extracting data due to the lack of API and documentation regarding tables and fields in the database. We can customize and use the CDSS accompanying the EHR; however, we are unable to create new CDS rules. The preceding limits us to creating assignments on features, functionality and usability.

Other departments may choose open source EHRs as Borycki and colleagues and Kushniruk and colleagues have done at the University of Victoria (Borycki et al., 2009b; Kushniruk et al., 2012a; Kushniruk et al., 2012b). They can also choose to implement both an open source EHR and a commercial EHR to leverage the advantages of each in teaching as Zhang and colleagues in the School of Computing and Software Engineering at Southern Polytechnic State University indicate they have done (Zhang et al., 2014). The decision rests with the department and its human and financial resources allocated for such implementation. Ultimately, the implementation of the EHR system brings HIT experience closer to the student. For instance, seeing the use of clinical decision support, even in a lecture to illustrate the interactions between Coumadin and Advil for a patient prescribed Coumadin, adds to the learning experience of the student who otherwise would have depended entirely on readings to understand the system and its concepts.

6. Conclusions

IS departments, due to their applied IT focus and expertise, are uniquely well-positioned to meet the HIT educational needs of healthcare professionals. Many departments in the health professions lack technical resources to adequately implement and integrate HIT in education. In particular, nursing and allied health programs face technical as well as financial hurdles in implementing EHR systems. They also lack the medical knowledge of physicians. Hence, it is likely more difficult to implement these systems. At NKU, the EHR system is implemented in the information systems department rather than in any of the health professions departments. Hence, opportunities exist in integrating hands-on exercises for students in health informatics as well as those in nursing and allied health. Some nursing programs are currently using Pearson's MyLab bundle. RealEHRPrep with iCare in the bundle offers a convenient way for faculty to include the EHR in teaching; however, it does not allow flexibility in designing and creating new and original assignments.

Furthermore, IS departments have the potential to move beyond this model and reach out to medical schools and programs to collaboratively offer rich HIT training and experiences using simulated EHR in medical education. Medical programs, too, face challenges in implementing EHR systems for education purposes. Medical schools and programs have relatively more financial resources than other schools and departments in the health professions; however, they too lack the technical expertise. The technical expertise that IS departments can impart combined with the medical knowledge in medical schools and programs can be leveraged toward designing training systems for optimal learning and use. First, research can be conducted to understand the challenges that these schools or programs—nursing, allied health, and medical—face in bringing hands-on EHR experience into the curriculum to further the preparation of their students and how these challenges are different from those present in IS departments.

Opportunities also exist for IS researchers in studying the impact of EHR-integrated educational experiences on student learning as well as on professional practice in all related disciplines—health informatics, nursing, allied health, and medicine. Next semester at NKU, we plan to collect data from students who use the eClinicalWorks EHR system for hands-on assignments in our undergraduate health informatics course 1) to examine if and how the EHR system affects student learning and 2) to resolve any issues in lectures and assignments.

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Appendix 1. Mock Patient Scenario

Patient #4

CC: 3 days of productive cough
Meds – OTC Mucinex DM
Medical history: Allergic rhinitis – OK on Claritin
All: Morphine: GI upset
Surgical History: inguinal hernia repair 5 years ago – no problems

Family History: Father: heart disease with bypass at age 60 years old, Mother with breast cancer died at age 68 years old
Social History: divorced. Lives alone. Has smoked 2 ppd of cigarettes for 30 years. Occasional alcohol use – negative CAGE ?s. Works full time as truck driver
Vitals: Weight: 240 pounds. Height: 5 ft, 11inches. BMI – 33.5, BP = 134/82, Pulse is 88 and regular. Resp: 18 per minute, Temp = 99.4

HPI: 52 year old male who developed productive cough with yellow phlegm for the last 3 days. Occasional wheezing with no dyspnea. No chest pain. No significant sinus symptoms. No sore throat or ear symptoms. No back pain No pain or symptoms into lower extremities. No fever or chills. Similar episode about 2 times a year – resolves with antibiotics. No history of pneumonia. Tried OTC Mucinex DM with some relief. No history of asthma or COPD. He has smoked 2 ppd for 30 years

Review of systems: History of allergic rhinitis. No GI or cardiac symptoms

Exam – Patient in no apparent distress.

TM, sinus, nasal mucosa, and mouth exam are normal. Neck is supple with no LN
Lungs are scattered wheezes and rhonchi. No rales. OK air movement
CV with regular rate and rhythm - no murmurs, rubs, or gallops
Abdomen is non-tender with no mass or hernia noted
Assessment – Acute bronchitis ICD #10 J20.9 tob use – ICD #10 Z72.0

Treatment: Antibiotic Zithromax – Zpack prescribed. Continue Mucinex DM OTC. Stop smoking. If any problems or not resolved, patient is to follow-up to reassess.
Visit code: Level 3 New patient

Follow-up if there is increase or no follow-up. To have regular checks at PCP
CPOE – no interactions or contraindications

Problem list – tob use

Preventive Medicine – stop smoking – cessation information given – to have regular check-ups, work on weight loss

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