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Implementing a Novel Interprofessional Clinical Informatics Curriculum

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A novel interprofessional clinical informatics curriculum was developed, piloted, and implemented, using an academic medical record. Targeted learners included undergraduate, graduate, and professional students across five health science colleges. A team of educators and practitioners representing those five health science colleges was formed in 2016, to design, develop, and refine educational modules covering the essentials of clinical informatics. This innovative curriculum consists of 10 online learning modules and 18 unique imbedded exercises that use standardized patient charts and tailored user views. The exercises allow learners to adopt the role of various providers who document in EMRs. Students are exposed to the unique perspectives of an attending physician, nurse, radiological technician, and health information manager, with the goal of developing knowledge and skills necessary for efficient and effective interprofessional communication within the EMR. The campus-wide clinical informatics curriculum is online, flexible, asynchronous, and well-established within each college, allowing faculty to select and schedule content based on discipline-specific learner and course needs. Program modifications over the past 4 years have correlated with a positive impact on the students' experience.

KEY WORDS: Clinical informatics, EHR, EMR, Informatics in healthcare, Interprofessional education

To deliver safe, high-quality care, healthcare professionals must be able to talk to each other about their patients. Effective communication and collaboration are identified as core competencies of healthcare professionals and optimize safety, patient outcomes, and cost savings.[1,2] A method for promoting patient safety and interprofessional collaboration at this large Midwestern university-based medical center is through the EMR. The EMR is a powerful tool for reducing medical errors and maximizing patient safety.[3] Healthcare professionals share the same medical records and have access to the same labs, imaging studies, procedures, and notes for their patients, in both the ambulatory and inpatient settings. Clinical informatics includes the knowledge of and proficiency with technology in healthcare and is fundamental to this process.

The American Medical Informatics Association promotes a formal clinical informatics curriculum as essential for all students in the health sciences.[4] Key concepts and skills related to healthcare documentation and data management should be acquired before health science students enter into practice.[5] A systematic review in 2018 identified a need for formal informatics curricula among healthcare professional students, as well as methods for measuring outcomes.[6] Despite the evidence, curricula that focus on clinical informatics and target the healthcare professional student are underdeveloped.[2] The purpose of this project was to address that gap and incorporate an interprofessional clinical informatics curriculum into multiple health science colleges and departments.

METHODS

Interprofessional education has been identified as a priority for all health science students.[7] It is identified as "an essential pedagogical approach in health care education, deemed as crucial in equipping health care professionals to deliver safe, high quality, and optimal patient care."[8] This novel curriculum targeted students from multiple health science colleges at a large Midwestern university and required representation of those varied perspectives on the curriculum development team.

Interprofessional Team Design

A team of content experts comprised of 29 health science educators, practitioners, and staff from multiple disciplines at a large Midwestern university met to design and implement an online, interprofessional, comprehensive, and evidence-based clinical informatics curriculum consisting of 10 content modules (see Table 1). The target learners included undergraduate and graduate students from the Colleges of Nursing,

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Table 1. Clinical Informatics Curriculum Modules and Content

Module	Key Learning Objectives	Reflected AMIA Competencies[4]
Clinical Informatics Introduction	• Describe how optimizing patient care by using tools to predict and prevent illness and maintain health is cost effective	*Social and Behavioral Science:* health promotion through informatics *Health Information Science and Technology*: methods and tools for solving biomedical or health information problems *Human Factors and Socio-technical Systems*: role of users in the design/application of information systems *Leadership*: behaviors for achieving informatics solutions *Professionalism*: privacy, confidentiality, security of patient data *Information Science and Technology*: concepts, methods for managing data *Social and Behavioral Aspects of Health*: models to manage/modify health of individuals and populations *Interprofessional Collaborative Practice*: team dynamics in solving complex health/health information problems
Telehealth & Imaging	• Discuss how use of images contributes to documentation of clinical conditions • Describe how telemedicine is used to provide specialty support from a remote healthcare provider	
Clinical Decision Support	• Provide examples of CDS types within EMR, identify value of preventing errors and adverse patient effects • Identify best practices for improved efficiency, cost efficacy, and patient outcomes	
Patient Engagement	• Discuss role of personal health records/patient portals and EMRs in patient self-management, informed decision making, and collaborative care coordination • Discuss use of patient-generated health data	
Health Information Exchange	• Articulate components of HIEs • Understand technical interoperability behind data transfer	
Documentation	• Explain (1) the advantage of discrete data entry in the context of CDS capabilities and data re-use and (2) the advantage of free-text entries in the context of patient care • Describe the role of templates and justify their appropriate use	
Privacy & Security	• Explain how HIPAA Privacy Rule's individual rights are applied to information in EMR • Describe security threats	
Analytical Use of Data	• Describe differences between types of analytic approaches • Illustrate critical role analytics can play in value-based care delivery healthcare with respect to quality/process improvement, cost containment, and population management	
Population Health Management	• Define population health • Describe tools that can be used for identification of populations and timely, efficient, evidence-based management of populations across the continuum	
Clinical Workflow Analysis & Process Redesign	• Identify effective techniques in negotiation, conflict management, and decision making to effect change in healthcare • Determine factors critical to a successful team • Develop a comprehensive communication plan for an IT project	

Abbreviation: AMIA, American Medical Informatics Association; CDS, Clinical Decision Support; HIEs, Health Information Exchanges.

Pharmacy, Medicine, and Social Work and the School of Health and Rehabilitation Sciences. The curriculum was piloted in 2017 and "rolled out" to students across multiple health professions. To this date, over 1750 interprofessional students have participated in and provided evaluative feedback on this innovative learning experience (see Table 2).

What optimized this curriculum and made it unique is that there is a pre-existing academic EMR (AEMR) used for education, which is a copy of the active system-wide EMR, but with all patient information removed. Students can access the same electronic environment that would be experienced in a real clinical setting, yet with simulated patient information.

Incorporation of Clinical Informatics Concepts

Curriculum development has been an iterative and collaborative process, beginning with a survey of existing evidence-based clinical informatics programs based on American Medical Informatics Association core competencies.[9] Consensus was achieved on 10 topics relevant for an interprofessional education program, including Introduction to Clinical Informatics, Telehealth, Clinical Decision Support, Patient Engagement, Population Health Management, Privacy/Security, Clinical Workflow Analysis and Process Redesign, Health Information Exchange, Analytical Use of Data, and Documentation.

Table 2. Clinical Informatics Curriculum Users by College, 2017–2020

College	AU17 (Pilot)	SP18	AU18	SP19	AU19	SP20	AU20
Medicine	17	0	0	7	0	15	0
Nursing	10	147	119	167	120	158	99
Pharmacy	10	133	125	0	120	0	135
Social work	5	7	0	13	10	9	10
Health/rehabilitation sciences	14	93	22 HIMS 31 Dietetics	47 OT	28 HIMS 19 Dietetics	0	26 HIMS
Total	56	380	295	234	297	182	270

Abbreviations: AU, autumn semester; HIMS, Health Information Management System; OT, occupational therapy; SP, spring semester.

Learning objectives for each module were created by an interdisciplinary team (see Table 1). Feedback was incorporated to address gaps or overlaps in the curriculum. Each topic was taught asynchronously and developed by primary and secondary authors as content experts from the academic and clinical perspectives. Faculty from nursing, medicine, pharmacy, physical therapy, occupational therapy, dietetics, and social work contributed, along with nurse practitioners, clinical physicians, clinical pharmacists, and clinical social workers. Experts from the information technology (IT) department completed the team.

Integration of Academic EMR Exercises

Innovative technology within the 10 modules linked content to 18 exercises in the AEMR (see Table 3). These exercises allowed students to see and engage with a fictitious patient chart while learning about clinical informatics.[10] Academic EMR exercises required multiple sign-on identities including that of the physician, nurse, radiological technician, and health information manager (see Table 3).

The AEMR was an exact copy of the current production environment of the medical center's EMR, strengthening the potential for students to see the EMR from multiple user perspectives. This "big picture" view was unique, since most exposure to the EMR is limited to only the role of the practitioner. Goals for students included a deeper understanding of how their EMR role interacts with others, how to leverage the EMR to improve care for their patients, and an increased familiarity with the EMR platform so that more efficient and effective care will occur when students reach the clinical environment. Such high-quality performance is associated with safer healthcare and optimized outcomes.[3]

Interactive sessions within the modules allowed students to view and listen to narrated slides, pause the narrative, log in to the AEMR, and follow instructions to complete exercises in the patient chart.[10] For example, the Clinical Decision Support module included an exercise where students logged on as attending physicians working in an ambulatory setting. The fictitious patient's chart revealed Health Maintenance Alerts (ie, recommended care such as immunizations and screenings). Logged in as the attending physician, the student was instructed to enter and sign an order for a lipid screening.

Students then switched log-ins and returned to the chart as inpatient nurses viewing the patient's health maintenance alerts, or care gaps, which included screenings for human

Table 3. Clinical Informatics Modules: Details of AEMR Exercises

Module Name	AEMR User Log-Ins	Setting(s)	# Patient Cases
Clinical Informatics Introduction (Electronic Medical Records)	Attending physician	Ambulatory	4
Telehealth/Informatics Imaging	Attending physician Radiology technician	Ambulatory	1
Clinical Decision Support	Attending physician RN	Ambulatory, inpatient	4
Patient Engagement in Electronic Health Records	Patient	Personal health record	1
Health Information Exchange	Attending physician Health information manager	Inpatient	1
Documentation	Attending physician RN	Inpatient	3
Privacy/Security	RN	Inpatient	2
Analytical Use of Data	None	None	0
Population Health	Attending physician	Ambulatory	1
Clinical Workflow Analysis & Process Redesign	None	None	0

immunodeficiency virus and tetanus. Students were instructed to click on those alerts and change them to "complete" so that they would drop off the list of care gaps. They addressed population health by running reports on their fictitious diabetic patients' hemoglobin A_{1C} levels. In the nursing role, students recorded vitals and noted trends. Logging in as the radiology technician required students to execute the begin/end workflows needed for a magnetic resonance imaging, whereas the Health Information Manager log-in required students to "break the glass" and navigate its consequences. Interaction in all four roles enabled students to "see" the uniqueness of each team member's focus and responsibilities within the EMR.

Primary to these hands-on lessons was a broadened understanding of the functions of other disciplines within the EMR. The informatics exercises facilitated understanding of and context to the topic. Students were exposed to tasks outside of their field and scope of practice that they would otherwise never do. As a result of "walking in the shoes" of their colleagues, students gained understanding of the uniqueness of each specialty's responsibilities within the EMR. This provided insight and perspective on the value and importance of interdisciplinary collaboration and management.

Launching a Novel Clinical Informatics Curriculum

Prior to launching the new curriculum, a comprehensive guide was developed ("IHIS Learn Guide") by the team's IT specialists. These tip sheets provided crucial information to students on accessing and navigating the modules and the AEMR. Quizzes and surveys were included with each module, to measure performance and to capture feedback related to knowledge and student experience. All students campus-wide followed the same weekly schedule for module completion, with each module expected to take 30-60 minutes to complete. During the pilot, only one module was released per week across campus, and all students followed the same schedule. This permitted a focused and module-specific IT support system. The general rollout of the curriculum allowed for asynchronous participation and faculty selection.

Assessment and Evaluation

The objectives of this evidence-based curriculum focused on standardizing and promoting knowledge of clinical informatics, building understanding of the interplay of healthcare team members' roles, and facilitating cross-discipline collaboration in the delivery of care.[9] The focus of evaluation was to measure knowledge of clinical informatics principles (via quiz performance) and to assess the student experience of utilizing IT to foster interprofessional development (through survey results). Module quizzes (six multiple-choice questions per module) were reviewed every semester to determine accuracy and item reliability. Five items tested knowledge, whereas one item directly addressed skills required in the AEMR exercise. On average, student scores ranged from 80% to 100%, but items with less than an 80% success rate were assessed, revised, and/or replaced as warranted.

Students were surveyed on module clarity, organization, ease of access, and level appropriateness on a 5-point Likert scale from "strongly disagree" to "strongly agree." One open-ended question elicited qualitative comments organized by the following themes: (1) technical issues delaying access, (2) audio issues preventing content clarity, (3) requests for more specific navigational directions in the AEMR (such as screenshots), (4) content complexity inappropriate for learner level, and (5) lack of familiarity with EMR use and navigation. Survey and quiz data were reviewed every semester to determine changes that would improve the student experience, including revision of any quiz questions that produced less than 70% answer accuracy.

RESULTS/LESSONS LEARNED

Optimizing the Learning Experience

Designing and implementing a technologically based interprofessional curriculum presented many challenges. Five years of efforts provided opportunities to reflect on successes and challenges. Primary issues surrounded resource shortages, access to technology, incorporation into pre-existing programs, and coordination of workloads and schedules in a very large university setting. Working through these issues was character-building for the team and for this novel curriculum.

Establishing an Interprofessional Team of Educators and Practitioners

Assembling an interprofessional team of educators and practitioners was essential to this program's success.[5] Twenty-nine clinical and faculty experts joined, including pharmacists, physicians, nurses, social workers, informatics specialists, dietitians, and occupational and physical therapists. Monthly meetings occurred online and in person, so that optimal participation was possible.

Logistics of Piloting and Aligning Modules With Existing Curricula

The clinical informatics curriculum was piloted in August of 2017 with 47 students from the colleges of pharmacy, nursing, medicine, social work, and health/rehabilitation sciences. Each module included five vital components: (1) Narrated Slide Presentation, (2) Module Summary (learning objectives and instructions), (3) Link to Exercises in the AEMR, (4) Module Quiz, and (5) Module Survey (evaluative questions). The pilot yielded crucial information on student perceptions, access, and execution.

Incorporating and assigning credit for the clinical informatics curriculum was at the discretion of each participating

college. Faculty had identified the barrier of requiring completion of one module per week, so that additional time to complete all 10 modules was created at the semester's end. Flexibility and opportunity were expanded for students. Further evaluation supported changing all 10 modules from mandatory to optional, allowing faculty to select the modules and schedules most appropriate for their learners.

Several colleges experienced a lack of open space or a home course where the modules would fit. The College of Nursing's graduate level informatics course embedded the modules and offered them in both semesters, whereas the College of Pharmacy could only offer them in the fall. The College of Medicine faced persistent challenges with module integration due to a tightly scheduled, year-round curriculum. Work continues to focus on how best to engage these learners in such interprofessional initiatives despite scheduling constraints.

Technology Challenges Related to a Rapidly Changing EMR

A major lesson learned, and unanticipated in the academic environment, is how rapidly changes occur to an EMR. If the teaching team's objective was for students to apply learning to the clinical setting, then it was imperative to monitor the constant updates and revisions to the EMR and, by extension, the AEMR. Quarterly updates to the AEMR required that IT specialists closely monitor and detect/report changes when features became inoperable. Updates to the technology led to obsolete exercises, outdated screenshots, and inaccurate instructions. The narratives and slide content then needed revisions of the simplest but most crucial details, such as a button's location on the AEMR page.

The difficulty with keeping the AEMR up-to-date and relevant was based on the clinical side of the academic organization. Goals for learners included understanding of how an EMR is built, how it works, and how it is used as a tool in daily clinical care. Application of this knowledge, as well as transference to other settings and EMR systems, was facilitated by a familiarity with the look and feel of the EMR. Sharing an outdated EMR version with the student had the potential to cause more confusion in the clinical setting versus promoting proficiency at the start of this initiative.

Prompt student notifications about the changes were needed, while dedicated personnel updated lessons and exercises to reflect the revisions. Module Log-In Guides, which provided log-in roles and patient names for each exercise, had to be updated as well. These costly and time-consuming consequences affected scalability and maintenance of the modules. To address this issue, developers are testing a process for making content more modular so that AEMR changes can be incorporated into the exercise instructions without affecting teaching content. The team is transitioning to the use of PowerPoint files to create the narrated modules. Changes will then not require a special recording booth or personnel to facilitate them.

Multiple Backgrounds and Levels of Learners

Students exposed to this novel curriculum represented every program level including undergraduate, graduate, and doctoral. Backgrounds represented social work, nursing, pharmacy, health information management systems, occupational therapy, dietetics, and medicine. Many students had little or no experience with an EMR, whereas others were clinicians with extensive working knowledge of the EMR. Significant barriers were expected in those seeing the AEMR for the first time.[11] The team considered developing a prerequisite module that would provide basic EMR training but decided that too many learners would find it redundant.

Instead, the faculty of each discipline selected students most capable of engaging with the AEMR and then matched the informatics module content with learner abilities to optimize learning outcomes.[7]

After the first year of implementation, module selection became college-specific and customized, based on the judgments of the faculty overseeing content delivery and best knowing student needs. For example, College of Social Work students focus on their role in medical/clinical settings, so that studying Clinical Decision Support and Documentation was a priority in preparing for practice. College of Medicine faculty collaborated with leadership to match content with learner needs and overcome scheduling obstacles. The result was incorporation of a modified Clinical Decision Support module into their summer curriculum.

There was wide variance in students' familiarity with informatics terminology. A glossary of terms was adapted from the Health IT Web site for each of the 10 modules, as a resource for understanding.[12] For example, the glossary for the Clinical Informatics Introduction module defined the term "best practice alert" as "a pop-up alert which notifies clinicians when they need to tend to important tasks." The Patient Engagement module's glossary defined the term "workaround" as "a bypass of a problem or limitation in the system; a plan to circumvent a problem without eliminating the problem."

Optimizing Student Experience With Complex Technology

Early and persistent barriers developed regarding use of the technology. Students frequently had difficulty accessing the modules and exercises. Logging into the AEMR required students to first download specific software onto their devices, which needed to be laptops or desktops to optimize the experience of interacting with the patient charts. The use of handheld devices was ineffective, which then required some students to have to be physically present in a computer lab on campus in order to complete the exercises. Toggling between the slides and the AEMR platform proved to be a

challenge for students without two computer screens and was addressed with step-by-step instructions on the slides. Module components were re-recorded, incorporating multiple improvements, in autumn of 2018, 2019, and 2020.

Accessing the AEMR required specific student accounts and specific passwords, which led to confusion because the accounts were similar to medical center accounts. To address accessibility issues, a recorded video message from a team member provided students with step-by-step log-in instructions. Access issues improved but continued, so a mandatory orientation exercise was created in spring of 2019 as a prerequisite, to provide students with a "dress rehearsal" with the new technology. Eight simple steps oriented students to the processes for downloading necessary software and logging into the AEMR. Students who encountered problems with technology (ineffective downloads, defunct passwords, or incorrect user names) were able to recognize and correct them prior to beginning the modules. A tip sheet on the log-in process was developed in August of 2020 as an additional reference.

Logging in to the AEMR required students to have three sets of information: (1) name and initials of unique patient assigned to the student, (2) department in which the patient was treated (inpatient unit vs ambulatory care clinic), and (3) role that the student was to play in the AEMR—nurse, physician, radiology technician, or health information system manager. During the pilot, students were vocal about frustrations and logistical obstacles experienced in the dual and synchronous activity (module content and exercises). Recorded narratives directed students on how to navigate through the AEMR. To address this challenge, a "Module Guide" was developed in table format, outlining module-specific details, including patient name, department, and student role for each activity. A list of middle initials (for fictitious patients) was assigned and posted for each student, ensuring that only that student had access to his patient's chart.

Figure 1 represents improvement in student ratings of accessibility of module content and exercises over time, using a 5-point Likert scale (1, strongly disagree; 5, strongly agree). Figure 1 shows an initial rating of nearly 4.2 during the pilot in autumn of 2017, then a drop to less than 4.0, and then a steady increase to over 4.2 by spring of 2020 (see Figure 1).

Learning Needs of English as a Second Language Students

Evaluative comments about unfamiliar terminology prompted the team to consult experts on best practices regarding English as a second language (ESL). Modules were modified to meet standards in online education for ESL students. The glossary, developed to ensure standardized definitions of key technical terms, was reviewed by a team of ESL experts at the university.

Assessment of Quality and Organization of Module Content

Student surveys were collected at each semester's end and evaluated module organization, clarity of content, and ease of access to the AEMR. The team reviewed these data monthly and generated enhancements to slides and narratives to address any barriers noted and to improve the student experience. Consistent improvement was noted in student ratings of module organization based on a 5-point Likert scale, where scores initially fell after the pilot and then gradually increased to a current rating of 4.4 out of 5 over the past six semesters (see Figure 2).

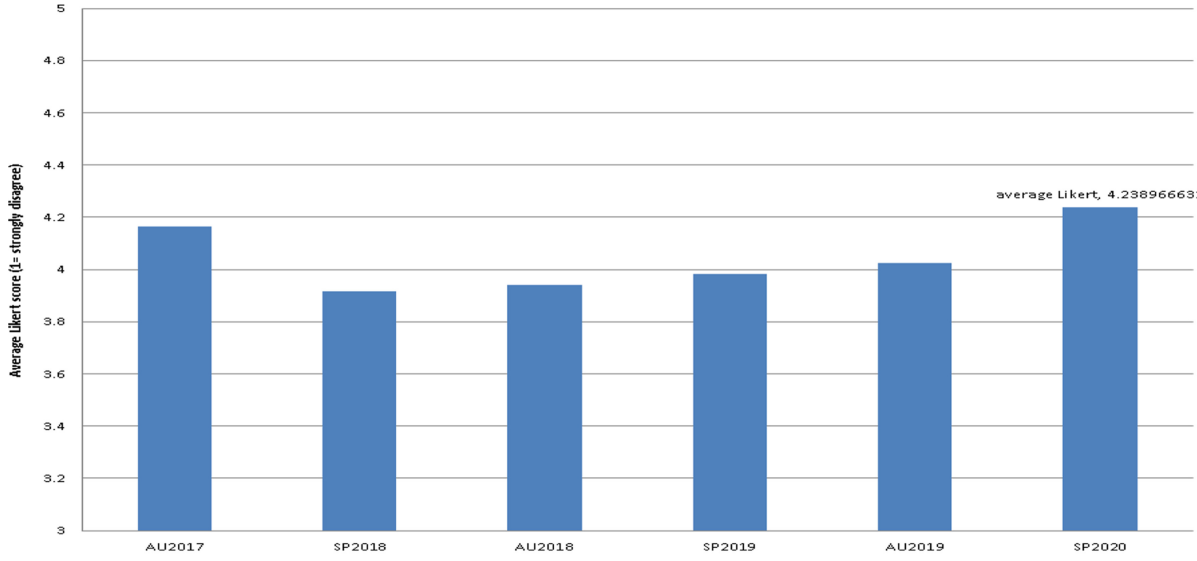

FIGURE 1. Student ratings of the accessibility of module content and exercises. Student ratings in each semester using a scale of 1 (strongly disagree) to 5 (strongly agree) for "I was easily able to access and use the AEMR based upon the instructions provided."

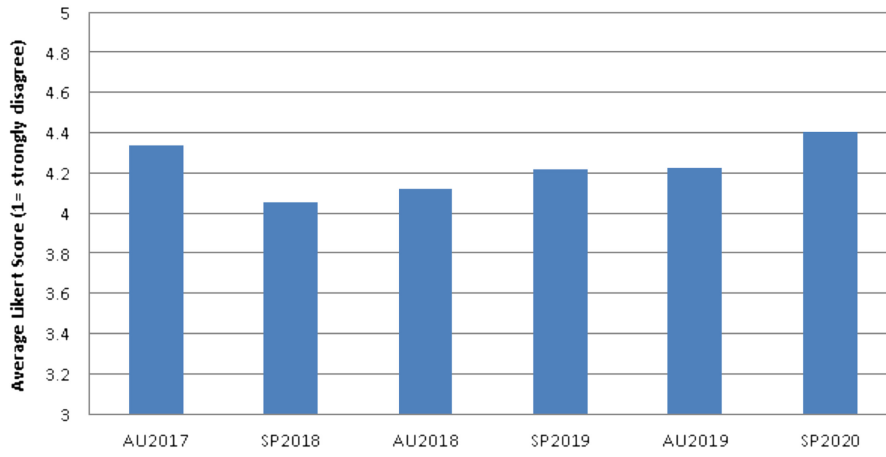

FIGURE 2. Student ratings on module organization by semester, 2017–2020. Student ratings in each semester using a scale of 1 (strongly disagree) to 5 (strongly agree) on "The modules were well organized."

Maintenance and Sustainability of Curriculum

A curriculum using high levels of technology is costly in terms of both money and resources. Implementation requires multiple individuals with expertise, including faculty who can manage a shared curriculum among various colleges and IT experts to manage the technology side of access and updating. Multiple individuals in the medical center as well as the IT department are responsible for steps in this process, as well as distribution of sign-on user names and passwords to facilitate AEMR log-ins. Students are assigned a set of unique middle initials for their patients, so that each has a unique patient chart in which to interact. All participating colleges must provide student names and medical center identifications so that IT specialists can create AEMR accounts.

Students' extensive use of technology has created a "24/7" access mentality, with immediate responses expected when problems are encountered. Learners demand ease of use and quickly become frustrated when unable to navigate an exercise. As the curriculum has evolved, it has become evident that long-term sustainability will only be possible with dedicated faculty coordinators and IT experts to manage it. Changes to foster maintenance and sustainability include creating modular versions of the exercises, allowing each college to set its own schedule for student access, and providing faculty and students with an "orientation module" where technology glitches could be handled early and swiftly.

Smaller academic institutions could implement a similar curriculum by partnering with the medical community where their health science students practice clinically. This partnership could result in the formation of an interdisciplinary and collaborative team of academic and clinically-based professionals on a smaller but representative scale. Student assignments could require access to, and navigation through, the clinical partner's actual EMR, while complying with privacy and security regulations.

Students engaged in patient care in the clinical setting could complete the informatics exercises in conjunction with those patient care assignments. Guided exercises, such as simulations, case studies, and scavenger hunts, could provide similar exposure to the unique roles of team members. An EMR exercise could require a review of the progress notes of multiple interprofessionals to determine the plans/priorities of each. Smaller organizations without an AEMR or a clinical partnership could still implement this curriculum by eliminating the AEMR exercises, focusing on clinical informatics content, and customizing the content to the needs of their learners.

Potential for Role Confusion

A key strategy in this curriculum was having students experience various roles within the EMR. This was a priority, due to the fact that the transition from paper to electronic charting has resulted in each user's differing view of a patient's chart. The advantage of an EMR is that each user has the tools needed to readily perform his or her primary function. For nurses, flow sheet rows and the medication administration record are most often used. Physicians review that information but do not chart it, resulting in differing views of those activities. Understanding the impact of each action on other members of the team is vital to healthcare quality and safety. An action left undone may not allow other team members to visualize the result. Although there may be potential for role confusion as a result of these module exercises, identifying the importance of understanding the role of all team members was most important for our learners to visualize.

CONCLUSION

Collaboration within teams and across disciplines is increasingly important in healthcare, as the focus shifts to value-based care delivery. Accurate documentation and clear dissemination of information are both crucial to optimizing patient outcomes. An EMR allows for efficient and effective communication between disciplines, but students often lack formal training and education in EMR usage. A novel clinical informatics curriculum designed by an interprofessional team of experts can prepare students to access and analyze data, use clinical decision-making tools, promote population health, and communicate with other team members. In AEMR exercises, students can immerse themselves in not only the role they will assume as professionals but also that of their future colleagues. The opportunity to learn about and "act out" the concepts of clinical informatics through their application in an AEMR is essential to achieving safe, evidence-based, quality care.

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