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DEVELOPING AN EMR TRAINING UNIT FOR NURSING AND MEDICAL STUDENTS

Master's thesis

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ÕENDUS- JA ARSTITEADUSÕPILASTE EMR SÜSTEEMI TREENINGÜKSUSE VÄLJATÖÖTAMINE

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Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

The aim of this master thesis is to investigate the feasibility of using Open Source EMR systems in order to teach nursing and medical students EMRS practical skills that are needed in their future job. The thesis consists of two main parts; selecting a suitable Open Source EMRS and developing an instructional unit for training students in order to use the EMRS.

The Analytic Hierarchy Process (AHP) was used to select a suitable Open Source EMRS. The training unit uses eLearning, problem-based learning, and case study to optimize the teaching methods. The potential learning objectives are defined by using the Revised Bloom's Taxonomy method. In the later parts, grading rubrics are created for the evaluation of the students' learning outcomes, while the quantitative and qualitative data analysis methods are applied to the evaluation of the two questionnaires.

The two questionnaires were conducted among the students from the German Furtwangen University in order to collect feedback from the students regarding the training unit and the assessment of using different EMR without any instructions. In total, 35 answers were collected from the first questionnaire and the results showed that over 80% of the students believed they knew how to use EMR after the class. From the 36 answers gathered from the second survey, the results showed that the majority of the students can complete tasks in a new EMRS without the guidance from the teacher. The students could also list the functions that a good EMRS should have from their practical experiences, such as user-friendly interface and help menu.

The results of the two studies have shown a positive impact of the training unit in the EMRS education, providing the students with the opportunity to have the first-time experience in using EMRS and the doctor's practice from the patient simulation.

Annotatsioon

Antud magistritöö eesmärgiks on uurida avatud lähtekoodiga EMRi süsteemi kasutamisvõimalusi õenduse –ja arstiteaduse erialal olevatele õpilastele, andes neile tuleviku tööga seonduvaid kogemusi. Töö koosneb kahest põhilisest osast: sobiva avatud lähtekoodiga EMRi valimisest ja EMRi kasutamiseks vajaliku juhtimisüksuse väljatöötamisest.

Alguses kasutati sobiva lähtekoodiga EMRi välja valimiseks Analüütiliste hierarhiate meetodit (AHM). Treeningüksus kasutab nii õpetamisel kui ka parimate tulemuste saamiseks nii eÕpet, probleemipõhist õpet kui ka juhtumiuuringut. Potensiaalsed õppimiseesmärgid on defineeritud kasutades Bloomi modifitseeritud taksonoomiat. Lõputöö hilisemates osades luuakse hindamismeetod õpilaste töötulemuste ülevaateks ning kahe küsimustiku lõpptulemuse saamiseks kasutatakse kvantitatiivset ja kvalitatiivset andmeanalüüsi.

Saksamaal asuvas Furtwangeni Ülikoolis viidi õppegrupiga läbi kaks küsimustikku, saamaks õpilaste käest tagasisidet nii treeningüksuses osalemise kui ka ilma juhisteta erinevate EMR süsteemide kasutamise kohta. Esimeses küsimustikus koguti kokku 35 vastust ning üle 80% vastanutest uskusid, et nad oskavad pärast loenguid EMRi kasutada. Teise küsimustikuga koguti kokku 36 vastust ning suurem osa õpilasi vastasid, et nad suudavad EMRi süsteemi kasutades lahendada erinevaid ülesandeid õpetajate abi kasutamata. Samuti suutsid õpilased oma praktilisele kogemusele põhinedes välja tuua erinevad omadused, mis mugaval EMRi süsteemil olema peaksid, milleks olid näiteks kasutajasõbralik liides ning abimenüü.

Küsimustikud näitasid positiivset efekti EMRi haridustaseme tõstmises, andes õpilastele võimaluse saada esimest kogemust EMRi kasutamises ning patsiendi simulatsiooni rakendamises doktori kogemusi saades.

List of abbreviations and terms

EMR	Electronic Medical Record
EHR	Electronic Health Record
EHRS	Electronic Health Record System
EMRS	Electronic Medical Record System
ACE	Alliance of Clinical Education
PBL	Problem-based learning
ACGME	Accreditation Council for Graduate Medical Education
eLearning	Electronic learning
RBT	Revised Bloom's Taxonomy
AAMC	Association of American Medical Colleges
QDA	Qualitative data analysis

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1 Introduction

Traditional nursing and medical students' education focus on medical knowledge rather than electronic medical records system (EMRS) in their field. Although EMRS has existed for more than 30 years and many healthcare organizations have adopted EMRS [26]. The practical use of EMRS education has not been added to the majority of medical education curricula yet. Nowadays, most hospitals or healthcare institutions are using the EMRS to manage patients' records [69]. Many people in the healthcare field use the term electronic health record (EHR) and electronic medical record (EMR) interchangeably, but Dave Garets and Mike Davis (2006) pointed out electronic health record (EHR) needs the electronic medical record (EMR) as the foundation and the EMR can only reach its full potentials with the existence of EHR [75]. In conclusion, the study of EHR will reflex a direct correlation with the status of EMR at the same time.

1.1 Background of the study

According to Young-Gun Kim et al. (2017) study of the adoption rate of the EHRS in South Korea in 2015, the adoption rate of EHRS has continuously raised [17], which may indicate that the EMRS is more commonly used in the healthcare sector. Students who study nursing or medical care will be the final users of the EMRS. Under these circumstances, developing an EMRS training unit is necessary.

As a recent study shows seventy-nine education deans of medical schools in the United States and Canada responded to a survey regarding medical student notes in the patient record, "*over 90% believed student notes belong in medical records, but only 42% had a policy regarding this*." 93% point out that without student notes, student education would be negatively affected [5]. Therefore, teaching students to write patient notes in EMRS is an important practice in their study. In the meanwhile, students' competency in the patient note writing and patient care can be improved by the EMRS training.

Nowadays, nursing and medical students not only need to understand how to treat patients but also need to know how to write medical notes, managing the patient chart and the medical records in the EMRS, which means using EMRS would become their routine in their future professional career. Learning the practical skills about the EMRS and using it as an assistant to provide better medical care to patients is essential. Additionally, medical record documentation is one competency that is required by the Accreditation Council for Graduate Medical Education (ACGME). It states that residents are expected to *"maintain comprehensive, timely, and legible medical records [3]."* The EMRS training can also engage students with patients besides learn to write medical notes, by involving them into the treatment team to understand the patients' status and playing their roles in the patient care.

Open Source EMRS has been mostly used by the hospital or other healthcare institutions who have a limited budget and cannot afford a commercial EMRS. Open Source EMRS is free and functional enough for the basic patient care. Moreover, it can offer a safe training environment for medical education [1]. In conclusion, an Open Source EMRS is a good approach to start the EMRS training with low cost. As a result, after the students complete the EMRS training in the school, they will be able to adopt a new EMRS faster in the future [1].

At the end of training, an adequate timely assessment is necessary. The evaluation provides feedback to the students, it helps them to understand their competencies in medical documentation and patient care. Additionally, it might provide a clear study direction for them to achieve higher levels of practice [2]. Direct observation is a useful tool in the assessment of medical students and it allows to document their practice by using screenshot function on the computer. On the other hand, the assessment is also valuable for the teacher, since they can find out their teaching results which will allow the teachers to improve their teaching methods if needed, thereby reaching their teaching goals.

1.2 Research questions

In 2008, Association of American Medical Colleges (AAMC) updated the recommendations for clinical skills curricula for undergraduate medical education, information technology skills are included in the recommendation. For example: using

software and web-based programs for eLearning and using the EMRS in the patient care [59]. Thomas Michael et al. (2006) has shown that 94% of the students communicate via e-mail and 97% of the students use the internet for information research, but only about 14% of the students have experience in using digital simulations (i.e. patient simulations). As a conclusion, the introduction to computers and education in the use of IT in patient care would benefit many students [58].

As stated in a survey of clerkship directors by the Alliance of Clinical Education (ACE):*" only an estimated 64% of programs currently allow students any use of EMR; of these only two-thirds allowed students to write notes within the electronic record"*. Clerkship directors were neutral about the effect of the EMRS on medical education, although they did recognize many advantages of the EMRS. Nevertheless, the concerns about their usages in medical education were also raising [4]. For instance, students can access the patient's information by looking at the patient's chart. Even though the students are required to have a permission in order to have an account in the EMRS with limited access, it still raised an ethical dilemma regarding whether the medical students should be allowed to have an access to the real patients' health records and to which extent.

The EMRS training for new employees has raised a new challenge for hospitals since new staff needs to know how to use the EMRS as a part of their job. Meanwhile, the hospital has around 10 new employees each month, and it is essential to give them a training of using EMRS in order to help the newcomers being familiar with their work [61]. Will the new employees' training process be expedited, if the medical education includes the EMRS training in their curricula?

In order to facilitate students with the EMRS practical skills, this thesis will design an instructional unit to conduct the EMRS education based on the case study. The purpose of this instructional unit is to create a more solid and efficient training unit for the EMRS practical skills education. By the end of the thesis, the instructional unit will be modified to be a better teaching approach according to the feedback gathered from the study group. In order to understand the shortcomings and the strengths of the designed instructional unit compared with other similar instructional units regarding the EMRS education. As a result, this thesis will review the previous literature and find out which parts of the instructional unit can be improved in order to provide optimal results.

2 Open Source EMRS

The Electronic Medical Record (EMR) is designed to save medical paper records or charts in digital form, it includes the patient's personal information; such as name, age, address, contact information, insurance and billing information [69] [70]. According to the U.S. Health and Human Services Department (HHS) defined the EMR as *"a digital collection of a patient's medical history, including diagnosed conditions, prescribed medications, vital signs, immunizations, lab results and personal stats like age and weight [7]"*.

Compared with commercial EMRS, Open Source EMRS reduces the barriers to adoption. Firstly, Open Source is free for implementation. Secondly, some vendors provide online demos which can be used to experience the functions of the system without installation. Thirdly, the source code is opened to all users, everyone can examine the source code and fix it if any security bugs are founded. While the private commercial EMRS developers control their source code of the software and keep it in secret. Also, Open Source EMRS provides more flexibility compared with the commercial ones. For examples, customization and modification are easier with an open source code. Lastly, the support of an Open Source EMRS is usually freely provided by the developer community, while the commercial EMRS companies usually sell their customer service along with their products [60].

Open Source EMRS has sufficient functions for fundamental digital healthcare practice [28]. It is normally produced and maintained by multiple institutions that aim to provide free EMRS for hospitals or healthcare organizations which do not have the budget for a costly commercial EMRS [23]. By facilitating them with the free EMRS, therefore helping them improve patient care quality and reducing medical errors, thus lowering the patient care cost and improving the working efficiency [25]. Collected data from EMRS can be used for improving management of healthcare institutions as well as medical studies. For instance, retrieving big data from the institutional database in order to conduct prevalence studies of certain diseases or making better preventive care plans to restrain the spread of infectious diseases in the future [24].

The EMRS is an important innovation in the healthcare field, since doctors, clinicians, nurses, and administrations use it for their daily work. The main purpose of the healthcare system is to keep patients' health records in digital forms, which gives an easier access to the data. It can also be retrieved and secondarily used for clinical research in the future [49]. The EMRS also provides an opportunity to share patient information with other healthcare providers timely and safely under regulations [50], hence allowing the doctor to make more accurate patient care plans according to their whole medical history.

Charles, D, et al. (2015) had a study about the adoption of the EHR among U.S. Non-Federal Acute Care Hospitals, in this study, the EHR can be understood as the EMR because of the study subject is hospitals, the results have shown that around 76% hospitals have adopted at least a basic EMRS with clinician note in 2014. Moreover, more than one-third of the hospitals were using more advanced EMRS which include the decision support function, clinical reminders, drug allergy results, drug dosing support and so on. 97% of these reported hospitals possessed a certified EMRS technology by the end of 2014 [6].

Many different EMRS have already been implemented in the healthcare sector, but there is no one universal EMRS [26]. For example, different interfaces, different functionalities, and different working processes in the EMRS. Instead, there are many standards for developing a standardized EMRS for future cooperation, such as HL7, DICOM and LOINC [27]. The requirements of EMRS for the basic functionalities in healthcare institutions are similar. For instance, they want a system that can help them to improve their care efficiency and lower the care cost. This means that users of different EMRS could encounter similar functions in the systems. For instance, searching the patient's information, scheduling an appointment, writing the medical notes, and making a care plan.

It's an opportunity to adopt Open Source EMRS for medical education; students can obtain the fundamental skills for using EMRS from practice and they need to utilize the knowledge they have learned to solve the scenarios in the EMRS. At the same time, an Open Source EMRS gives them unlimited access and sufficient time in using EMRS. Therefore, the students will have the chance to thoroughly consider and interpret information by themselves during the practice process, generating necessary

information for making a diagnosis or a care plan. This can help students in understanding the real-time patient care and matters that require attention. In order to realize that many stakeholders and companies need to work together in order to support the development of the EMR by funding and sharing the resources with each other to improve the qualities and the functions of the EMRS [29]. In the long term, the Open Source EMRS provides potential users with the opportunity of experiencing a well-designed EMRS for free.

2.1 Using (EMRS) eLearning for teaching nursing and medical students

One of the challenges medical educators are facing is maintaining the respectable education while they also need to put in efforts in order to keep updating the changes in the healthcare system [34]. Moreover, due to the diversity of the students, one teaching method is not enough to satisfy the needs of all the students since they have different personality traits. For example, some students might like lectures, and they can learn well from theoretical information, while others might prefer practical studies which will motivate them more and allow them to learn more efficiently [12].

Technology has advanced over the years, commercial content and applications developed dramatically after the invention of World Wide Web (WWW) [40]. Nowadays people have the much easier and quicker access to online resources than ever before. People have witnessed the impact of technology over the decades and our perception of the world and experiences have been greatly changed because of the internet [36]. From the film projector and radio that have been used in the classroom in the 1920s [44], to the personal computers and smart devices (i.e. iPad, virtual reality) that are used by educators now. Furthermore, when the first web education report in medical field happened in 1992 [41], it was a big evolution in the medical education. Nonetheless, technology has always stayed at the forefront which is driving the education to reform [42]. From the history of technology in education, although the rigidity and resistance to reform happen quite often in public schools, the technology still has brought some big improvements in the public education [44].

The eLearning method is an electronic learning way to delivery knowledge or information without time and location limitation by using computers or electronic devices to connect to the internet and learning in the online environment [31]. The study shows that eLearning has been adopted and used by many medical institutions in order to enhance students' individualized learning competence [38]. While eLearning can enhance effectiveness as well as productivity [32], the development of the internet, search engines, open universities and open libraries also allow students to access useful information faster and more accurately. The study has shown that medical students can improve their learning outcome through eLearning method [33].

A typical traditional education usually involves texts, lectures, books, the classroom, a teacher and a blackboard. The teacher gives lectures and the students listen while taking notes [37]. However, this old fashion way has been limited to a certain form, time and location. Face-to-face teaching restricts what and how the knowledge will be taught, therefore, the quality of education will greatly depend on the teacher, instructional design, experiences, and the budget.

Implementing eLearning to medical education can assist educators in improving their teaching methods, utilizing online tools and resources, empowering students to control over their own learning pace, content, time, and location. Meanwhile, the students can create their own learning objectives and gain experiences, controlling their learning orientation and the results [35]. Additionally, educators can use online tools to support students learning activities. For instance, the teacher can create an online course, post related documents, articles or videos in the study forum. The teachers can also grade the homework, open an online group discussion and answer students' questions, which allowing them to monitor the students' study process [43].

However, traditional teaching methods have their own special advantages, namely allowing the teacher to observe students closely and explaining the knowledge in more detail when needed. The students can sit and work together in order to solve the problems and the school can build a comfortable environment for students, therefore be allowing them to focus on their studies. Accordingly, combining the most efficient parts of traditional teaching and eLearning method to create a strong fundamental frame for modern style teaching, by utilizing resources that medical education has and designing a blended learning method. The new method can reinforce learning effects with the

assistance from technology and customized eLearning program to fit the students learning demands [35, 39]. Moreover, with the vast online open database and technologies, teachers and students can keep up with the newest trends, knowledge, and tools. eLearning can be the remedy for the deficiencies in traditional educations.

Open Source EMRS provides educators with the opportunity to bring the eLearning to the traditional classes. Furthermore, the students can start using electronic devices to connect to the internet and enjoy online studying resources. eLearning and the EMRS both increase the possibilities to provide students with valuable learning experiences [11]. Additionally, the EMRS as an eLearning method opens the door for students to understand the modern health care system more thoroughly. The path of learning with eLearning and EMRS will be similar to their predecessors, so no matter the student's first feeling towards the digital medical systems, eventually they will evolve and make the most use of the EMRS for their purposes.

2.2 Comparison of different Open Source EMR systems

According to the result of A.A. Zaidan et al. (2015) [8], the GNUmed, OpenEMR, and OpenMRS are the top three systems from the result of ranking score records. In order to evaluate the EMRS, the following criteria of the EMRS were used: usability, competencies requirements of medical students, implementation duration and the flexibility of the system.

There are many research papers that have conducted studies about the criteria of the EMRS in view of the medical education objectivities and goals [8]. One of the requirements is that the system needs to support different user roles for simulation. Another feature is allowing the teacher to check students notes in the system, while the teacher can also make comments or assessments in the system. The interface should be user-friendly and the usability should match the needs. Eventually, seven criteria have been chosen as reference attributes for selecting the suitable EMRS for the training unit.

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method. It was originally developed by Prof. Thomas L. Saaty in 1970. In short, it is a method for handling complex decision; it provides a possibility to make the decision according to multiple attributes, while also offering a comprehensive and rational framework in order

to deal with the multiple-factors scenarios and evaluating different alternative solutions to the problems. However, inconsistency can happen whenever the human being makes the judgment. Hence, Prof. Thomas L. Saaty used consistency index (CI) to measure the degree of consistency. Furthermore, he used consistency index to compare with the random consistency index (Table 1) in order to get the consistency ratio; the inconsistency is reasonable if the consistency ratio is equal to or smaller than 10%, otherwise, the judgment should be adjusted to a reasonable range.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 1. Random Consistency Index (RI)

This thesis used Thomas L. Saaty's AHP method in order to select the most suitable EMRS from GNUmed, OpenEMR, and OpenMRS for the EMRS training unit. The whole selecting process starts from structuring the problems into a hierarchy (Figure 1). At the top level is the final goal that needs to be accomplished. Seven criteria for making the decision are located at the second level. The last level (bottom level) consists of three alternatives that need to be evaluated by considering criteria from the second level.

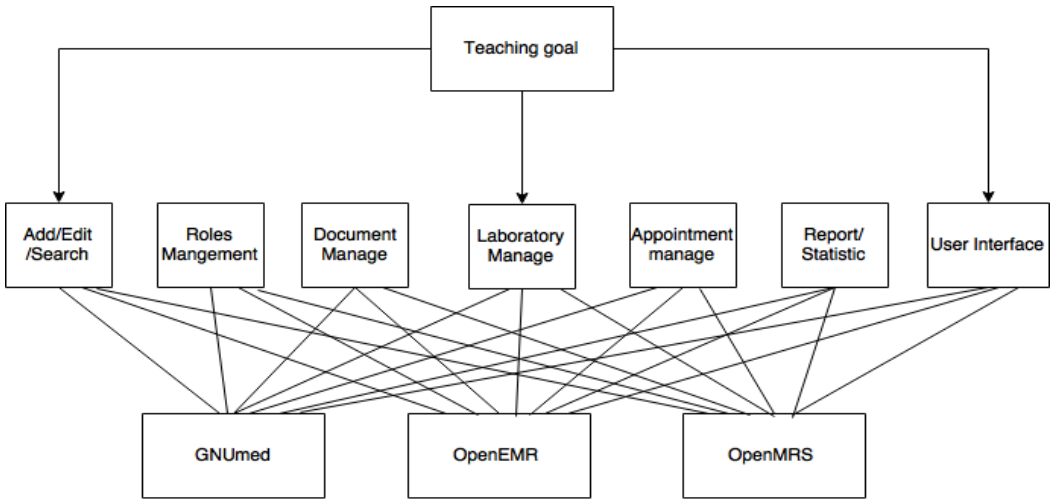

Figure 1. AHP hierarchy

There are 7 important criteria in total that are identified in order to help the author of this thesis to select a suitable Open Source EMRS for training unit. The following paragraphs will show some descriptions of the selected criteria.

A. Adding, editing and searching the patient: Adding a new patient, editing patient's information if there is something that needs to be changed, searching for a registered patient information in the system.

B. Roles Management: The ability to manage users and change roles for the users when their responsibilities have changed. For example, when a nurse got a promotion and become an administrator in the management board, he or she can still use the original account to log into the system, but he or she has higher authorization than before. The possibilities to create a customized role. for example, the original system doesn't support the doctor creating an appointment for the patient, but this can be changed by the administrator and added to the schedule function in the doctor's account.

C. Document Management: Patients' laboratory test results, the referral letters, discharge letters or any other necessary documents should have the option to be archived and retrieved, uploaded and downloaded from the system.

D. Laboratory Management: Doctors or nurses can order a laboratory test and read the test result directly in the EMRS. Medical laboratory technicians can upload laboratory results into the system by themselves.

E. Appointment Management: Scheduling appointments, editing appointments or canceling appointments.

F. Report/Statistic: The options of creating patient reports and having the possibilities in providing useful statistic reports for the management.

G. User Interface: Friendly user interface can improve efficiency and motivation for the users, while, a well-structured interface can save time for people and expediting the training process.

After selecting and defining the criteria, the following steps are used to make pair-wise comparisons judgments. Firstly, listing all possibilities of pairs from criteria and adding the judgments into a matrix (Table 2). Judgments need to reflect the lecture goals and give a score to each criterion by using the fundamental scale of AHP; the highest score should be given to the most important criterion and the lowest score to the least important one.

Criterion	A	B	C	D	E	F	G	Prority Vector
A	1	3	5	6	7	8	9	39.36%
B	1/3	1	3	5	6	7	9	24.09%
C	1/5	1/3	1	3	5	7	9	15.88%
D	1/6	1/5	1/3	1	3	5	7	9.63%
E	1/7	1/6	1/5	1/3	1	3	5	5.72%
F	1/8	1/7	1/7	1/5	1/3	1	3	3.33%
G	1/9	1/9	1/9	1/7	1/5	1/3	1	1.99%
λmax=8.2611								

Table 2. Pairwise comparison matrix for the criteria

Table 2 shows the judgments matrix of all the pair-wise comparisons for the selected criteria, which is followed by the rules that the criterion compared with itself will always be assigned with value 1. The numbers one, three, five, seven and nine equate with the judgments "equally important", "moderately more important", "strongly more important", "very strongly more important" and "extremely more important" [30]. The numbers two, four, six and eight are comprised of previous values. Putting reciprocal values in transpose position. Accordingly, there are twenty-one pair-wise judgments. Next step is using the comparison matrix in order to get the priority vector which is also called normalized principal Eigen vector.

The priority vector result shows (Table 2) that the criteria A, B, and C are the most important criteria. The next step is to make comparison matrix of the alternatives with each criterion. There are three alternatives and seven criteria, therefore, seven 3*3 matrixes are created, as shown in table 3.

Crieria A	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.33	0.25	12.26%
Open EMR	3.00	1.00	0.50	32.02%
Open MRS	4.00	2.00	1.00	55.71%
sum	8.00	3.33	1.75	
λmax=3.097, CI=0.049, CR= 8.36%				

Crieria B	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.20	0.17	8.19%
Open EMR	5.00	1.00	0.50	34.31%
Open MRS	6.00	2.00	1.00	57.50%
sum	12.00	3.20	1.67	
λmax=3.122, CI=0.061, CR=10.51%				

Crieria C	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.33	5.00	28.28%
Open EMR	3.00	1.00	7.00	64.34%
Open MRS	0.20	0.14	1.00	7.38%
sum	4.20	1.48	13.00	
λmax=3.097, CI=0.048, CR=8.27%				

Crieria D	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.33	0.00	16.67%
Open EMR	3.00	1.00	0.00	50.00%
Open MRS	0.00	0.00	0.00	
sum	4.00	1.33	0.00	
λmax=1.333				

Crieria E	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.14	0.33	8.82%
Open EMR	7.00	1.00	3.00	66.87%
Open MRS	3.00	0.33	1.00	24.31%
sum	11.00	1.48	4.33	
λmax=3.01, CI=0.005, CR=8.62%				

Crieria F	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.33	0.00	16.67%
Open EMR	3.00	1.00	0.00	50.00%
Open MRS	0.00	0.00	0.00	
sum	4.00	1.33	0.00	
λmax=1.333				

Crieria G	GnuMED	Open EMR	Open MRS	Priority Vector
GnuMED	1.00	0.33	0.20	10.62%
Open EMR	3.00	1.00	0.33	26.05%
Open MRS	5.00	3.00	1.00	63.33%
sum	9.00	4.33	1.53	
λmax=3.055, CI=0.028, CR=4.74%				

Table 3. Pairwise comparison matrix for the alternatives

The author of this thesis summarized the whole alternatives comparison process for each criterion in the following paragraphs in order to provide text information regarding the table 3.

Criterion A: three systems have the similar process in order to create a new patient and search for a patient's information, but OpenMRS requires the user to fill address and GNUmed requires a detailed address to be filled before saving the information. Nonetheless, they all support edit "patient information" in the search result window.

Criterion B: OpenMRS, and OpenEMR have the similar processes to manage accounts from the system of the administration menu. They allow the administrators to create a new account with defined capabilities while also supporting the existing account editing capabilities, as well as creating new roles or canceling certain ones. GNUmed cannot directly create a new user since it requires adding the person in the system first, and then enlist this person as a user. But GNUmed provides the ability to edit user menu in order to adjust account function, which is fairly complex compared with the other two systems.

Criterion C: GNUmed requires selecting the patient before allowing to start the process of document management. For examples, document review, exporting, printing or uploading. OpenMRS only provides patient records merging function. However, the OpenEMR provides document uploading, downloading, as well as writing referral function. Therefore, OpenEMR fulfills this criterion best.

Criterion D: OpenEMR has the function to create a new procedure, such as procedure order, a recommendation or a discrete result. At the same time, it also provides access to upload lab test results or review lab results and generate an electronic report accordingly. However, Open MRS doesn't provide this function. With GNUmed it is possible to add a new measurement, a procedure, and to view test results. Due to OpenEMR offers more options in operating laboratory functions, the highest score of criterion D goes to OpenEMR.

Criterion E: the user can easily create a new appointment and manage the appointments in OpenMRS. For instance, the user can create a new appointment provider according to the different type services. Then according to the request for appointment to assign patients to available doctors. OpenEMR can add a new appointment from the calendar

page and manage appointments from the calendar section. The user can directly view each day's schedule by clicking the dates from the calendar. GNUmed supports the overview of appointments and the waiting list. However, it does not support creating an appointment by the doctor.

Criterion F: OpenMRS does not have the report statistic function. GNUmed supports system statistics, such as medical problems, total EMR entries, documents, test results, procedures, vaccinations and so on. OpenEMR can request a patient's report, creating an electronic report.

Criterion G: GNUmed has a very old interface style that put different functions together with the menu bar and drop-down list and it is difficult to find information when all information has been shown in the same limited space. OpenEMR's default page has a calendar and shows appointment from the calendar and it also has the menu bar at the top of the screen. The interface of OpenEMR looks clear and simple, making it easy to navigate the system. OpenMRS needs to choose which department the user wants to visit at the login page, such as inpatient ward, laboratory, registration desk etc. Each session of OpenMRS provides their adequate function for users, with the simple and convenient layout of the interface. Therefore, OpenMRS got the highest score for this criterion.

2.3 Choosing a suitable Open Source EMRS for teaching nursing and medical students

Each criterion is defined by the characteristics of medical education, taking the learning objectivities and goals into consideration in order to reach the fundamental skills of using the EMRS. A user-friendly interface which consumes less time to complete tasks is also taken into account. By putting the pairwise comparison matrix of criteria and alternatives (Table 2, Table 3) together, the table of criteria and alternatives is formed. As the table 4 shows, GnuMED gets 0.142 points, OpenEMR gets 0.419 points and OpenMRS gets 0.396 points. Therefore, OpenEMR is the most suitable Open Source EMRS for the EMRS training.

	A	B	C	D	E	F	G	
Criteria	**0.394**	**0.241**	**0.159**	**0.096**	**0.057**	**0.033**	**0.020**	**Composite Vector**
GnuMED	**0.123**	**0.082**	**0.283**	**0.167**	**0.088**	**0.167**	**0.106**	**0.142**
Open EMR	**0.320**	**0.343**	**0.643**	**0.500**	**0.669**	**0.500**	**0.260**	**0.419**
Open MRS	**0.557**	**0.575**	**0.074**	**0.000**	**0.243**	**0.000**	**0.633**	**0.396**

Table 4. Result by comparing each criterion with alternatives

3 Open Source EMRS from a technological perspective

According to the result from chapter 2, OpenEMR will be used in this thesis as a teaching tool for teaching nursing and medical students EMRS in the EMRS education. Installation of the EMRS for preparation of the class needs to be finished before the start of the class. With the personal experience of the author of this thesis, the whole process is quite simple and quick. The local server for running the EMRS can be installed in one computer, after which it can share the server with other computers by using the connected local network [14].

3.1 Hardware and software requirement

The OpenEMR installation does not have any specific hardware requirements; every operating system can be used to install the EMRS. The database, Web server and PHP are prerequisites for running the EMRS on the computer. Unless the user chooses to install XAMPP stack to fulfill these prerequisites, the user needs to install and configure MySQL (or MariaDB), Apache and PHP5 before the EMRS installation can take place.

3.2 Installation and adaptation process

OpenEMR supports many different operating systems installations. For example, it supports Windows, Linux, OS-X, and VirtualBox. Because of Windows and OS X are the most commonly used operating system by our potential users [55], this section will mainly introduce Windows and OS X installation processes, even though the general processes are similar in most operating systems. Meanwhile, the other operating systems installation manuals can still be found in the online OpenEMR wiki page [14].

For Windows installation, the process can be done by using pre-configured OpenEMR with XAMPP or by the regular installation. There are two options for this installation: to install OpenEMR as the service or not as the service. The process starts by downloading the installation package version 5.0.0, then right-clicking the downloaded file and selecting ‘Extract All…’. When installing OpenEMR as a service, the user needs to

double-clicking C:/xampp/xampp-control and choose 'Run as administrator'. If OpenEMR is not installed as a service, then click 'start' MYSQL and apache. Next, the user can log into the account from the website with the local server (http://local/host/openemer). The initial username is admin and the initial password is pass [54].

As a part of the software requirement, the installation of OpenEMR on Windows with regular installation package first has to install and configure MySQL (or MariaDB), Apache and PHP5 first. After successfully installing the required software, the user should download OpenEMR from the SourceForge webpage, extract the downloaded package and change the name of the openemr-5.0.0 directory to "openemr". Then the directory should be under the web server root directory, while also referring to the web server documentation to obtain web server root directory. Next step is opening the web browser and pointing it to the installation script at http://localhost/openemr, following the installation instruction and finishing the process. After a successful installation, the initial login username and password and the link for opening the OpenEMR will be shown at the bottom of the last page [53].

The OpenEMR installation on OS X, with the installation of XAMPP stack and OpenEMR method, differs from the Windows one. Firstly, the user needs to stop another running Apache server or MYSQL if there is one currently running. Then, the user needs to download the XAMPP Version 5.6.30/ PHP 5.6.30 for OS X and install it on the Mac. Before finishing the installation of OpenEMR, the user should not start Apache nor MYSQL or create a database. The next step is downloading and installing OpenEMR after completing the installation of XAMPP. OS X also uses WEB GUI for the setup, and the user should follow the guidelines to finish the whole installation process. The installation guide can be found at OpenEMR Wiki under the section 2.8 in installation manuals subsection [56].

3.3 Maintenance

EMRS is used for collecting patients records in digital form, it contains many patients' private data, and M van der Haak et al (2003) study mentioned that *"Security and protection of patient health data are not only demanded by the patient himself, but in most developed countries they are also required by law."* [68]. A major concern of data

maintenance is its safety and consistency. Even though the teaching method is using scenario for simulating case study, the understanding of the essence of security will help users to establish a broader perspective of the most valuable and vulnerable part of EMRS, therefore, knowing the system can sustain the safety only when every user keeps the security concern in mind and plays his or her roles in order to protect it.

The second major concern of maintenance is system UI and functionality. This thesis uses standard installation and UI features while the real end-users are more diverse and have different requirements towards to functionality and the UI. Open Source EMRS offers many possibilities to customize the system according to users' daily work requirements and special usage purposes. The technician who has knowledge of computer science and EMRS design can easily redesign and implement the whole system. However, the customized project might consume more time and money, which should be taken into consideration before making the decision. This section can be elaborated when targeted groups are future technicians in the healthcare technologies, hence, it is possible to extend this section when it matches the teaching curriculum.

The most common methods to keep system consistency and safety include keeping login password in a safe place, changing the password frequently, scanning the computer for the malware frequently and using a firewall for system security. Additionally, the updates for software in order to fix bugs should be installed whenever possible and use the officially released updates is the easiest way. Nonetheless, errors need to be fixed when any problems are detected. These recommended methods can be used to reduce the risks of security, enhancing the functionality of the system and supporting the continuous system development [67].

3.4 The students (users) training

A successful implementation of EMRS needs to fulfill many requirements. As the EMRS uses modern technology, a sufficient user training will be beneficial for improving the user experience and interaction [18]. Exposure to the training could also increase the user acceptance of EMRS [19]. Training is also one key part of the class where the students learn to use the system which can help them to build more confidence in order to finish the tasks before the case study starts. The target student group should have the basic knowledge and skills about computer and healthcare since

the usage of EMRS requires some computer science and medical knowledge. The introduction of EMRS will be demonstrated with real practice. It is also necessary to have a technician who has a technical background and who is familiar with the database, server, and EMRS, in order to support the software installation, solve the unexpected errors and provide maintenance when necessary.

The training should be performed in a classroom with 20 to 40 seats and each seat needs to be equipped with one computer for participants. The classroom should also include a projector which matches the classroom size and serve as a tool for the teacher to give lectures. When the number of computers is limited or there are more students than computers, it is possible to share one computer with 2 to 3 users in order to continue the lecture. The guideline for practicing the EMRS can be printed out and handed out, or shared in a digital version to every participant at the beginning of the lecture. In order to provide students with good assistance, the instructor needs to understand the knowledge relating to the teaching subject, which is having medical knowledge regarding case study, the practical skills of EMRS and adequate teaching competencies [14].

The attendance of this training is mandatory and should be completed before the case study, the tasks relating practical skills will be demonstrated in the training. Second training would be beneficial when the updates of the software are released. The scenario and the tasks should be adequate and suit the background of target users. To establish different level system performance practices for different level students is necessary and valuable part of creating the curriculum. The teaching scope should be advanced within the years, therefore to enhance the understanding of the EMRS and practical skills.

The goal of this section is to provide sufficient knowledge about principle and framework of EMR system. After the training, students can distinguish different roles in the system, such as the role of the doctor and the nurse. Students can also perform basic tasks in the system. For instance, registering a new patient, inputting the patient's data, making an appointment for the doctor visit and searching the patient's information. More detailed descriptions of the training can be found in Appendix 1 and 2. The author believes that a brief introduction to the outline of the course and teaching plan can help students establish their own learning goals and do more meaningful learning during the study. The students should also understand the importance of course continuity that can help students build a continuous study process.

The selected Open EMR system provides online documents support for users [52], and it is easy to find the solutions for common problems at the forum webpage. Meanwhile, the developers provide online message function which allows users to consult with them about problems directly. The speed of response is fairly fast from the personal experience of the author of this thesis.

The feedback of the training will be collected in the form of the questionnaire; the evaluation will be performed after collection of questionnaires, which will be introduced in the results chapter.

4 EMR instructional design and scenarios

This thesis used eLearning method, the PBL method and patient simulation to teach students the fundamental practical skill of EMRS. Furthermore, medical scenarios are tailored to target students according to their medical knowledge background, since the main purpose of this instructional unit is to address the basic skills of EMRS rather than the teaching the medical knowledge.

According to the Accreditation Council for Graduate Medical Education (ACGME), there are six core competencies identified in order to maintain quality education for residents and safe care for patients. These are patient care, medical knowledge, practical-based learning and improvement, interpersonal and communication skills, professionalism and system-based practice [45]. These six competencies are meant to improve quality care and professionalism. The instructional unit is designed by following these six parameters in order to achieve the required competencies given by ACGME.

This instructional unit requires students to do self-learning and group work to finish the tasks from the case study. The whole instructional unit (Appendix 1) includes 3 lectures with 45 minutes for each lecture. Before the class starts, the teacher is required to prepare at least one computer with a EMRS installed beforehand for each group to use. Adequate medical knowledge for the target students is required and the teacher also has to prepare different user accounts before the beginning of scenarios practice. The procedure of this instructional unit will start with the teacher giving a brief introduction of EMRS and then demonstrating examples of tasks in the chosen EMRS at first 45 minutes of the class. The next step is to divide students into several groups, with 3 to 5 students being an ideal size for each group. After forming the groups, the group members should discuss and assign different roles to each of the group member, such as a doctor, nurse, and patient, assigning rest of the students as the nurses if there are more than 3 people in one group. Lastly, each group will get a randomly selected scenario and switch the scenario for each group after the completion of the first scenario practice.

Grading is a beneficial part of the whole instructional unit. The students can understand how much new knowledge they learned and to which extent based on their grade. On the other hand, grading can help the teacher to identify the teaching results. Considering the characteristics of group work in eLearning, PBL method and the length of the lecture, one possibility for grading students is peer assessment. In order to minimize possible bias, mutual grading should be avoided; the students' name and gender information should be hidden from the answer sheet. One possible substitute method is let students write their code in the answer sheet according to randomly created students' code list, then randomly pass the answer sheet to the students. Students who have their own answer paper need to replace it with another one while the evaluator should write their code on the paper for the teacher to confirm the information. The students' codes need to stay confidential and only the teacher should have access to the code list. In the meantime, students need to keep the screenshot of each step and document them in a word file, handing the final file to the teacher. This file can give the direct image of the practice process and the results of the study. At the end of class, the teacher should pass the questionnaire of the instructional unit to students and collect back the answers.

4.1 Background of nursing and medical student teaching in defined group

The target group is the second-year student group from the Furtwangen University in Germany. The scholars study the applied health science program at the faculty of Health, Safety, Society. The study program aims to cultivate students with competencies about design, planning, and implementation of technical assistance systems in the healthcare institutions and workplaces [16]. The study also requires the students to find the barrier of practical application of technical solutions and find the approach to fulfill the users' wishes. After graduating from the study program, the students should be able to work as a mediator between humans and technology. The curriculum of this program includes practical assignments and research projects, where the students need to work with practitioners in the field and be capable of developing potential on-site solutions individually [16].

Regarding the aim of the study program from the target group, the author of this thesis believes that using an eLearning method is a good approach to teach EMRS along with

the problem-based learning method and a well-integrated case study for the practice. The following section will discuss problem-based learning, explaining the reason to use it and the method to implement it into the instructional unit design.

4.2 The literature of other similar EMRS training units

All founded relevant studies of EMRS training from the online database will be used for comparison with the designed instructional unit in this thesis. The author of this thesis used Google Scholar as a searching engine for finding the relevant literature from the mass online database. The keywords are used for searching literature, such as medical student, nurse, EMR, EHR, instructional unit, class, training and medical education. These keywords are combined with each other in different orders in order to have better search results and to find more potentially relevant studies. The next step is selecting the most relevant studies from all kinds of searching results. The relevant information can be found from the titles, abstracts, and full paper contents. After going through the first page of the search results with each possible keyword combination, the author of the thesis identified two pieces of literature which were considered as the most relevant studies regarding EMRS training unit.

The first literature is from Stephens et al. (2011), which brought out the RIME scheme for education approach to clinical documentation in EMRS using the Accreditation Council for ACGME core competencies, *"the RIME scheme is an accepted framework for describing and assessing a students' progress through the stages of medical education."* RIME stands for reporter, interpreter, manager, and educator which are the four stages of medical education. Furthermore, the study mentioned that the correspondence of the EMRS skills is data entry, data assessment, data assimilation and clinical decision. The RIME scheme focuses on fulfilling core educational competencies and follows the learners' progress in patient care and clinic development [72].

Jeanne E. Frenzel (2010) was the second relevant study that compared with the instructional unit from this thesis. Jeanne E. Frenzel (2010) created 12 patient cases for simulation practice in an EMRS and implemented the EMRS practice in Pharmaceutical Care Laboratory III course. It also included the disease state management activities in patient-centered care practice, *"activities were designed to correlate with course content taught in a weekly 1-hour pharmaceutical care lecture series and didactic*

coursework." [74]. A pre-course and post-course surveys were used to assess students recognized gains in knowledge and attitude towards using EMRS for patient care. It also used grading rubrics to assess SOAP note [74].

4.3 Problem-based learning case

Problem-based learning (PBL) has been used for over 40 years since its introduction to medical education. It is not a teaching approach that focuses on students problem-solving skills, but rather than a way that uses problems to engage students in critical thinking and self-learning. This method can lead to a more efficient learning [46]. The original purpose of PBL was to solve students' unsatisfactory clinic performances while traditional teaching style failed to equip students with adequate competency to solve real clinic problems. In the PBL, the teacher works as a tutor to make sure students achieve learning goals and provide bits of help when students encounter problems. The author of this thesis believes that introducing the PBL method in the instructional unit will match the EMR training goal. In general, students can rarely learn in a meaningful way when the task is unclear. In conclusion, problem-oriented learning method drives the students to learn in a more meaningful and efficient way [9], [10].

Compared with the traditional teaching where the instructor does the teaching and students mostly listening, the PBL method requires students to be more active in learning [46]. For example, the students conduct a research, thinking independently and working in a solution-focused way in order to solve the problem. Besides these traits, the students also required to learn collaboration with others and work with different feedback. As a result, PBL can improve their interpersonal and communication skills, and be achieving better competencies in self-directed learning, information seeking as well as effective learning [48].

Using suitable problems to increase self-learning and understanding are the characteristics of PBL, in which the students gain knowledge by solving problems from the case study. In the beginning, the students define the problems. After that, they need to learn more in order to solve the problems when current knowledge is not enough. Students are the center of this method [46], they are self-directed and work with their team members [47] by dividing the task into smaller tasks, then delegating all tasks to each group member. Next, the students need to work on their own tasks, and after they

succeed completing their task, they collaborate with their peers and solve the problems by combining the solved tasks. It might take a few repetitions to solve all the problems and everyone in the team needs to play their own role while also making assessments of themselves and their peers. The students learn to monitor their process by themselves and make suitable adjustments to achieve the final goal. With this method, tutor's main responsibility is to facilitates the whole process and provide necessary support whenever needed. The key point of PBL learning is that the teacher provides minimal guidance and encourages students to solve problems by themselves rather than just giving them the answers directly [10] [46].

The common way to conduct PBL method starts with forming a small group of students, which usually is between 5 to 8 people in one group. First, the students need to define roles for each group member. There will be a scribe whose main responsibility is to keep accurate notes about the group meeting. Then there is a chairman who acts as a leader to make sure everyone has their tasks and ensures that the team is working towards their final goal. Firstly, the group members need to sit together and read the information carefully, since every bit of information that has been provided can be useful, defining the problems and the final goal. After reading the information, the team needs to define what is it that they already know and what they need to learn. Secondly, the students should divide the problems into smaller pieces and delegate specific problems to each group member. After that follows individual research for their next meeting where the students discuss what they have found from their previous research. Then they put all their information together and they need to repeat the process again until all problems are solved. During the process, the students need to share their knowledge and findings with their peers in order to solve the whole task. Also, the students need to handle the critical assessment from their peers [10].

4.4 Potential learning objectives with Open Source EMR systems in line with the Revised Bloom's Taxonomy

eLearning has been adapted by medical educators for many years [41], while the adoption rate of EMRS in medical institutes is increasing [6]. Consequently, the integration of the EMRS with medical education is an inevitable result of the digital world of today, which can ease the conflict between students' demand and medical

school curricula. The ideal teaching model is to conduct a continuous EMRS training throughout three years' study period for medical students, which helps them to establish comprehensive competencies with the simulated patient practice in the EMRS. In the meantime, it is important to adjust difficulties according to students' school year and creating the adequate curriculum to facilitate the students with enhanced learning, which results in a better performance outcome.

The learning goal of this instructional unit is to educate students with the basic skills of using EMRS through the patient care simulation process in the EMRS. Therefore, the students can gain practical competences of the EMRS after they finishing the instructional unit.

This thesis uses the Revised Bloom's Taxonomy (RBT) to discover the potential learning objectives for this instructional unit. The RBT has two dimensions, which are knowledge and cognitive process dimensions. The knowledge dimension has four main categories: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. The cognitive process dimension includes six categories in the verb form, such as remember, understand, apply, analyze, evaluate and create [57]. The learning objectives are mainly defined by the competence requirements for using the EMR, such as navigation in the EMRS and performing the certain tasks regarding the patient care. Such an essential EMRS supports many different functionalities. For instance, new patient registration, creating a visit, keeping medical notes, laboratory, document treatment plans [51]. These necessary functionalities might be used daily, hence, by the end of the lecture, the following learning objectives should be achieved:

1. Students understand the concept of the EMRS. (Evaluation method: simple written text/multiple choice)

2. Students can list different parts and functions of the EMRS. (Evaluation method: simple written text/ multiple choice)

3. Students improve interpersonal, communication and teamwork skills. (Evaluation method: peer assessment)

4. Students can perform following activities in the system independently: registering a new patient, search for a patient, schedule an appointment for the

patient, write medical a note and diagnosis, order an examination for the patient, upload the test result, write a nursing care plan. (Evaluation method: performance checklist with actual practice)

5. Students can use the help menu or the wiki from the EMRS provider to solve practical problems when they occur. (Evaluation method: performance checklist with actual practice)

6. Students can evaluate each other's learning outcome according to the grading criteria (Evaluation method: Table 6).

7. Students can use an EMRS from other companies or organizations. (Evaluation method: using the same scenario to examine practical skill in an EMRS from other company)

8. Students can list the places where EMR systems are used. (Evaluation method: text/oral/multiple choice)

9. Students can write down the necessary steps to achieve the EMRS processes. (Evaluation method: written text)

10. Students can explain the necessary steps to achieve the EMRS processes. (Evaluation method: written text)

The defined learning objectives can be put in the following tables which are created according to the RBT method. The identified learning objectives are shown in Table 5.

The knowledge dimension	The Cognitive Process Dimension					
	1.Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
Factual knowledge	Objective 2, 8					
Conceptual knowledge	Objective 9	Objective 1, 10				
Procedural knowledge			Objective 3, 4,7	Objective 5	Objective 6	
Metacognitive knowledge			Objective 3			

Table 5. The classification in a Taxonomy table of objectives in EMRS learning

4.5 Scenario design and chosen diseases for the specific scenario

A well-designed case study needs to be a part of the instructional unit in order to achieve the learning objectives. The study group is second-year medical students who have studied anatomy and some other basic subjects relating to the medical field in their first year. The purpose of the scenario design is to build the case study upon the realistic situation where students gain practical skills of using the EMRS. The practical tasks are distributed according to the real patient visits, diagnosis and treatment processes. The author of this thesis also considered the difficulties of each task, which is why the order of the tasks are formed by taking difficulty factors into consideration.

The scenario starts with a brief introduction of the disease and a short background introduction of the patient; such as name, age, gender and the living address. The description of a disease is beginning with patient's verbal description of his or her complaints to the doctor, followed by a detailed narrative of their symptoms and information that can help the students reach the diagnosis. The narrative part does not directly include doctor's questions, but by the patient telling symptoms instead. It is possible that making a correct diagnosis might be too difficult for students who only had a one-year medical knowledge study. However, this instructional unit does not aim to exam the medical knowledge of the students; it is rather than teaching the students EMRS practical skills. The cases that have been used are aiming to simulate more realistic patient care scenarios for students to practice in the EMRS.

The tasks are separated into three steps, mainly for dividing the lectures into the smaller length of classes according to the schedule of curricula and the teaching approach of the medical school. The steps can be combined or separated into more steps according to the requirements of the curricula. The order of each task should not be switched, but it is possible to carry out minor changes. For instance, it is possible to switch the order of the two consecutive tasks in the condition that they are not against the doctors' or nurses' working procedure.

Regarding the selection of specific diseases for the scenario, by considering the teaching methods and competences requirements, along with the teaching purpose, the author of

this thesis believes it is more important for students to practice in the system rather than to solve complicated medical symptoms. Therefore, the author selected three common diseases for the case studies, thus lowering the requirements for students' medical knowledge and focusing on students' understanding of the procedure of the EMRS instead, such as input and the output information in the system, searching the needed information and being familiar with the provided functions in the system.

Three chosen diseases for the case studies are *"A man with chest pain", "A lady with trouble sleeping" and "A gentleman with back pain"* [71]. These are general descriptions from the perspective of the patients while there could be various causes. Therefore, the doctors need to ask more questions to get more information for diagnosis. Students can pay attention to which part of the information has been revealed by the patient, the relevant answers are included in the text and all of the tasks can be finished according to the article. The solutions can vary since there are many different facilities and technologies that can be used for assistance. The solution might also be different compared with the real-life situation. However, these will not affect the training in the EMRS. While being involved in the problem-based study and eLearning method, the students are encouraged to find solutions by themselves with assistance from online resources or libraries.

5 Case study process and evaluation

According to the length of lectures and the teaching aim, the whole case study is divided into three separate parts. It is possible to make adjustments for these steps or processes them according to the different needs and goals. The author recommends conducting the teaching process starting from the easy level and gradually raising the difficulty.

5.1 Case study process with the chosen EMRS

The case study includes three different scenarios where the students need to learn specific skills of the EMRS, for instance, keeping a record of blood pressure, heart rate, blood test and monitoring the vital signals of the patient throughout the treatment period. According to defined learning objectives and learning goals, the author of this thesis selected three different scenarios for the case study. The scenario starts with patients describing their problems, after which the doctor starts to ask questions regarding the information that may be related to the illness. The narrative finishes with the patients' answer. Each scenario has the same three steps and tasks; lectures are separated into three smaller sections. The first step starts with easier tasks in order for the students to get to know the system, and followed by the diagnostic and treatment procedure. The three different scenarios allow different teams to practice more than once when they switch between the scenarios and the whole lecture is designed to finish within 90 minutes.

5.2 Example scenarios for the case study

The title of the first scenario is called "a man with chest pain". The student can get the basic information from the description of the title. The following information consists of the patient's personal information; such as name, age, address, ID code and weight. The scenario begins with the patient telling his reason for coming into the hospital, when the symptoms occurred, how the symptoms felt like and what is the current situation. The patient also uses a numeric scale to describe his pain, which was 8/10 in the beginning.

The scenario continues with the description of his medical history, past behavior and chronic diseases, such as high blood pressure and cholesterol, and treatments such as taking tablets for treating these diseases. The article also includes information about the patient's living habits, such as smoking, drinking or exercising.

In the next scenario, there is a lady who has trouble with sleeping. This case uses a 46-year-old lady as the study subject. The information includes her height and weight, which can be useful information for creating a new patient in the EMRS. The lady said that she has lost 8 kg over 6 months, but her appetite has been fine. The students can exclude the food intake as a reason for losing weight from this information. The lady has been working out regularly for many years. She has diarrhea that started 4 months ago and it hasn't improved since that. She has heart racing problem, but there are no obvious triggers. The patient also experienced hand trembles at times. She has no other medical problems and she does not normally take any medications.

The last scenario describes a gentleman with back pain. The gentleman is a 50 years old man who showed up at the clinic since he has serious back pain when he does heavy lifting; the pain began when he did heavy lifting; it is a constant ache and sharp lower back pain whenever he tries to bend; but he doesn't have any weakness or numbness, no weight loss, fever or sweat either. The patient has high blood pressure, but he is rather fit and well. His wife and he do not smoke or drink and his occupation is being a lorry driver, and he himself hasn't traveled anywhere in a year.

5.3 Evaluation methods of the case study

The last part of the EMR training is grading the students' learning outcome. Grading provides direct feedback for the students in order to understand their study results and motivating them to continue learning and improvement [22]. There are few different ways for grading. For example, 1 to 5 scale grading or pass-fail grading. While a paper questionnaire will be used to collect feedback from the students at the end of the course. It is important to analyze their feedback data in order to use it to improve the teaching method and to reach teaching goals by understanding and taking students' opinions into consideration. This section will discuss evaluation methods for grading students and questionnaire. The comparison of similar instructional units for the EMRS education will be conducted based on the literature review.

5.3.1 Methods for grading students

There are some different ways to evaluate students, one of the most common evaluation method is weighted categories. For example, using A to F scale, or 1 to 5 scale. Another way is to use Pass/Fail grading method, which only indicates whether the students passed or not, ignoring the scale of the result. This thesis uses rubrics as a tool to create evaluation criteria for grading. Teachers can use rubrics to show their expectations and the satisfaction level of those expectations. Rubrics can better help the students understand the teachers grading criteria and obtain knowledge accordingly in order to meet the expectations. Rubrics can also help students have clear criteria to judge themselves or their peers. Beside the grading system, the rubrics also gives sufficient information for students to know the level that they have reached according to the teacher's expectation and which parts of the study need improving [21].

Rubrics are usually displayed in a table format where the students can use to find out their missing and accomplished parts. Meanwhile, teachers can use it to check the performance of their students. There are few things that need to be avoided when using rubrics. First, the designer should avoid the use of elusive languages, such as "important". Secondly, avoiding unnecessary negative words, such as "boring" [21]. This thesis uses 8 criteria and 4 different levels of quality for scoring the students (Table 6). When the student has more than 3 criteria that he or she did not pass, he or she has failed this course. If the student attains at least 5 criteria, he or she passes the course. It is also possible to weight the result and give a scale level scoring where the instructor needs to set the percentage for each criterion and then use the level of quality times percentage and summing up all the results, which gives the final result. For instance, registering new patient in the system gives the students 20% of the final score and the criterion's quality level is 3, therefore, this criterion's final score is 3*20% which equals 0.6. By calculating each criterion's final score and summing them up, the teacher can get the final score of the student. If the total score is equal to 1, the student has failed the course, but if the final score is bigger than 1, he or she has passed the course.

Quality / Criteria	Excellent (4 points)	Good (3 points)	Poor (2 points)	Unacceptable work (1 point)	Score (1,2,3,4)
1. Register new patient in the system	Know how to navigate the system and add a new patient to the system.	Know how to navigate the system, but don't know how to add a new patient.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
2. Search for a patient in the system	Know how to navigate the system and search for information.	Know how to navigate the system, but don't know how to search.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
3. Write medical a note in the system	Know how to navigate the system and write notes.	Know how to navigate the system, but don't know how to write notes.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
4. Write the diagnosis in the system	Know how to navigate the system and write diagnosis.	Know how to navigate the system, but don't know how to write diagnosis.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
5. Order the examination for the patient in the system	Know how to navigate the system and use the system to order the examination.	Know how to navigate the system, but don't know how to order the examination.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
6. Upload the test result in the system	Know how to navigate the system and upload test	Know how to navigate the system, but don't know how to upload	Don't know how to navigate the system, but know how to	Don't know how to navigate the system and don't know how	

	result.	test result.	use wiki/help.	to use wiki/help.	
7. Schedule an appointment for the patient	Know how to navigate the system and make an appointment.	Know how to navigate the system, but don't know how to make a correct appointment.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	
8. Write the nursing care plan in the system	Know how to navigate the system and make a nursing care plan.	Know how to navigate the system, but don't know how to make a nursing care plan.	Don't know how to navigate the system, but know how to use wiki/help.	Don't know how to navigate the system and don't know how to use wiki/help.	

Table 6. Rubric for grading students

5.3.2 Evaluation methods for the questionnaires

At the end of the class, a printed questionnaire paper (Appendix 3, 6) is used to collect feedback from the students. The questionnaire is about the course design, the context, and suggestions. Some parts of the questions are answered with a rating scale which will generate quantitative data, which will allow to carry out the statistical analysis of the data that is based on the principles of mathematics. However, some answers will be collected in the open-ended narrative form and the two combined forms are used to conduct the questionnaires. The purpose of using the open-ended narrative form is to collect more direct feedback from the students who can freely express themselves. Therefore, the evaluation of feedback needs to deal with both quantitative and qualitative data.

Quantitative data analysis is an approach that includes the technique that the analyst uses to convert collected data to numerical data in order to carry out a statistical analysis, which is usually used for the support or contradiction of the ideas or hypothesizes that have been brought out earlier [65]. This thesis study will use Microsoft Office Excel as the tool to analyze the study data, transforming all the paper information into its corresponding digital form, then using PivotTable and chart functions. The answers will be affected by responders' attitudes and backgrounds, such as their gender, study field,

study year, computer competence, age. However, data should not be manipulated in the survey; the author cannot change any information in the questionnaire [64]. The analysis process requires critical and rational thinking since the same set number of the data set can be interpreted differently, hence, the analyst needs to make a cautious and fair conclusion.

Qualitative data analysis (QDA) is the procedure that organizes collected data into an explanation, understanding or interpretation of the people or the situation that are being investigated. The purpose of QDA is to examine the meaningful and symbolic content of the qualitative data. The process starts with sorting the data and extracting keywords, then grouping the data into different categories. Some students might describe things in a short version, while some of them might talk in a very detailed manner with different aspects [62]. In the Qualitative Data Analysis book [63], the author brought out three steps of data analysis, which are data condensation, data display, drawing and verifying conclusions. Data condensation is considered as one part of the qualitative data analysis, by selecting, summarizing and rephrasing data in order to transfer large raw data in a certain way with a recognized pattern. Data display as one major part of the analysis process means "*an organized, compressed assembly of information that allows conclusion drawing and action"* [63]. Graphs, charts and a matrix can be used as a good display approach for qualitative data. Then displaying data in a compact form in order to facilitate the expression of whole information, as well as verifying the conclusions. After data collection, the following step is interpreting the information from a vague stage and organizing it to a much clearer conclusion while maintaining openness and skepticism that are important for the process in the conclusion verifying. Reviewing all data from the beginning of the data analysis, replicating the findings and separating them into different concepts then categorizing them and confirming the data plausibility as well as justifying the conclusions to get a fair result.

The first step for analyzing the results is to read through all the responses. It is possible to find similar answers even though everyone will use their own words to describe their opinions. Categorizing the answers according to the similarity of them. However, it will still be still difficult to classify them all. But the idea is to generate some keywords from the answers and making different categories accordingly. After making categories, they should be used to mark the answers, keeping in mind that one answer can have more

than one category. The next step is to analyze the categories. If one category shows up often; for example, “book” appears in more than 50 percent of the categories, then creating a subcategory can help to evaluate the data better. For instance, subcategories of the word “book” can be “music book”, “geography book” and “traveling book”. The closer view of the answers is required and it might need to be adjusted and categorized to make the answers match better.

The following step is about finding the patterns about the categories, whether one category is relating to another one or triggered by the others. Patterns might lead us to some conclusions. Some relating answers can also be used to create a solid conclusion [20]. The author of this thesis followed all of the steps from above in order to get the results of the questionnaires.

6 Results

This thesis conducted two questionnaires in order to collect the necessary data from the students. In order to obtain the information and protect the students' privacy, a voluntary and anonymous approach was used to collect the answers. The first questionnaire is carried out with the aim of improving the instructional unit's designing, while the second one is used for studying the contribution of this instructional unit towards the students' EMRS practice skills.

6.1 Results of the questionnaire about the instructional unit

The first questionnaire got 35 answers and its results can be seen in Appendix 5. There were 32 females (91%) and 3 males (9%) who answered the first questionnaire, with the average age of the study group being 22 years old. All of the participants are studying applied health science and they are in their third semester of the study at the time of carrying out both of the questionnaires in this thesis. Some of the respondents did not answer all the questions, but all the answers that have been written are analyzed according to the collected information.

From the first question *"How do you consider your computer skill?"*. 60% (n=21) believed they have good or better computer skill compared with the average computer users, while 40% (n=14) think that they have poor computer skill. To the question of *"Have you used EMR systems before this class"* (Q2), 91%(n=32) answered they have not used it before. However, 3 participants have used the EMRS before, such as one student who used it during him or her work in elderly care for 3 years. One of the other students who had prior experience with the EMRS used it as a medical assistant. The third student used it during his or her doctor's practice in his or her previous study.

When asked (Q3) *"How long did it take for you to complete each task?"* (Figure 2), the average duration used for completing step one was 21 minutes in practice at scenario A, but it was reduced to 15 minutes in scenario B and C. Step two took an average of 18 minutes to be completed during scenario A and B practice, but it was reduced to 15

minutes during the last scenario. Step three took an average of 19 minutes during the scenario A, 16 minutes during the scenario B and it decreased to an average duration of 14 minutes in scenario C. After completing the tasks, the students were asked (Q4) *"Which task was the most challenging for you in the instructional unit? Please explain the reason."* EMRS installation (27%, n=13) and uploading the test results (27%, n=13) were the two most challenging tasks for the students. 16% (n=8) of the students have mentioned that creating a nursing care plan was difficult for them. Some of the participants told that the first time scenario practice (4%, n=2), along with the non-native English language (4%, n=2) with a complicated system (4%, n=2) made it hard for students to complete the tasks. There were few students who answered that they did not notice the existence of the EMR guideline for practice (n=1) or finding the correct assignment for each step (n=1), or just did not understand the instructional unit (n=1).

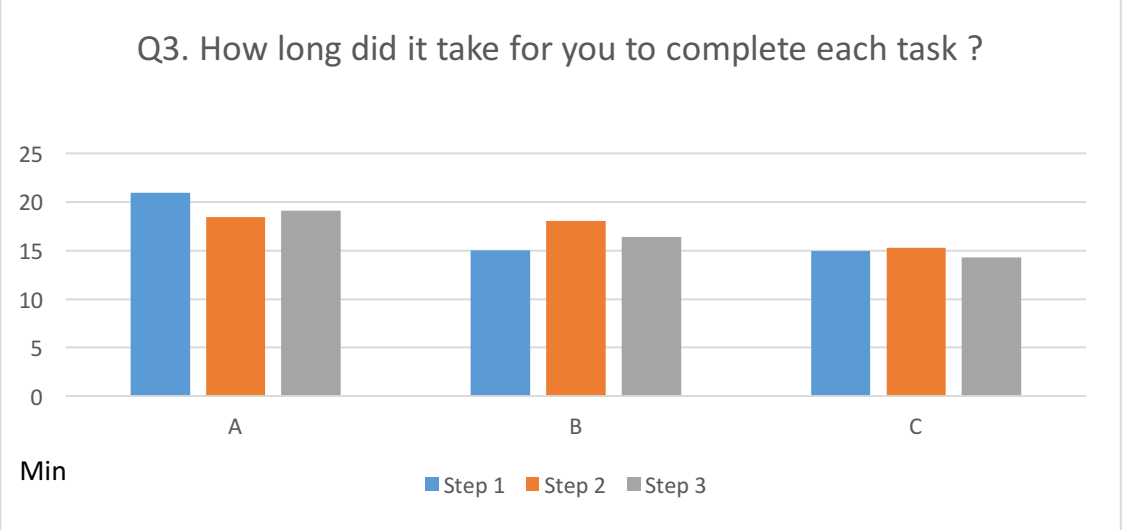

Figure 2.The average duration used for each step during the practice of three different scenarios

To the question (Q7) *"What did you find valuable/positive in this instructional unit?"*. Majority of the students thought that the demonstration of the scenarios and the guideline with descriptions of each task in detail (59%, n= 19) are the most valuable parts of the instructional unit for them. Some of the students considered that they got to know the EMRS from this instructional unit since it showed all of its basic features (16%, n=5). Regarding the experience and feedback about the class in general, three students (9%) mentioned that teamwork is a valuable experience for them for their future work. Four students (13%) believed that it is advantageous for them to learn the first eHealth software in their study program. There was also one student (3%) who was excited about the practical doctor's experience. When the students were asked about

(Q8)*" What would you change/improve in this instructional unit?"* Redesigning the interface of the EMRS for a clearer and easier usage is brought out by many students (18%, n=7). Needing an instructional unit language in German has also been mentioned by five students (13%). Some students also wanted to have more details about system installation (13%, n=5) and lesser screenshots requirement (13%, n=5), which were the main answers from the participants. Four students (10%) said that they would like to practice scenario twice rather than three times. 10% (n=4) of respondents wanted to have more medical knowledge that helps them with the practice of the case study in the instructional unit, 8% (n=3) wanted to have a clearer instruction in the class and two students (5%) wanted to have a longer length of the class in order to learn well. One student also mentioned that having more pictures in the instructional unit would be beneficial in order to better understand the assignment.

Students were asked (Q9) *"Do you think that you know how to generally use EMR systems after finishing this instructional unit?"* 83% (N=29) of the students felt confident in using the EMRS after the experience they got with the instructional unit. Six students (17%) felt their abilities to use the EMRS are still poor after completing the class. In reply to the question (Q10) *"What would you like to additionally learn about EMRS systems besides what has been taught in this class / this instructional unit?"*, five students (36%) answered that they want to learn all kinds of functions that are provided by the EMRS. 21% (n=3) pointed out that they want to practice different roles in the system, three students mentioned that they want to learn how to implement EMRS in a smart tablet. One student (7%) mentioned that he or she wants to practice telemedicine in the EMRS. One of the students (7%) wanted to experience how different roles communicate in the system or watching how a real doctor or nurse uses the EMRS. To the question of (Q11) *"What are your suggestions for further improvements in the practical teaching of EMR instructional units?"*, some students (n=12, 28%) needed more help and assistance with the installation of the EMRS, while 12% (n=5) of the students wanted a longer introduction to the EMRS. A better introduction or using a study theme for EMRS introduction was asked by four of students (9%). Four students (9%) wanted to have a better method for taking screenshots or just to capture less screenshots in general. Using video tutorials or the students' native language for the instructional unit has been equally mentioned by 9% (n=4) students. Providing more time for the practice (n=3, 7%) or using smaller tasks (n=3, 7%) were brought out by

students as well. There were two students also suggested to give more guidance for the tasks and one student wanted to practice an EMRS that has been adopted by the real hospital.

6.2 Results of the examination of the EMRS practical skill and the second questionnaire

The results of the examination of the EMRS practical skill and the evaluation of the second questionnaire are shown in Appendix 7.

The second study (Appendix 4) used the first scenario from the designed instructional unit as a case study and used the OpenMRS to examine the students' practical skill of using a new EMRS. Due to the OpenMRS not supporting upload test function, the second task from the step 2 has been removed from the second study. The students are assigned with the tasks from the first scenario with an exception of the second task from the step 2. However, from the collected results, the author of this thesis noticed that some of the students still tried to complete the task which was removed from this study. At the end of the class, the students are required to answer the questionnaire about the second study. The questionnaire got 36 answers in total and all of them were analyzed by using quantitative and qualitative data analysis methods.

The first question *"How long did it take for you to complete each task? Did you finish the whole step?"* (Table 7). Most of the students (94%, n=34) finished first step with an average duration 20 minutes. However, there are 2 students (6%) who spent 67 minutes on average and did not finish the whole step. The second step which has 36% (n=13) of the participants finished the step with 6 minutes on average, when many students (n=23, 64%) failed to complete this step overall. 72% (n=26) of the participants have finished the last step quickly with an average duration of 14 minutes. There were 10 students (28%) did not manage to finish all the required tasks in this step.

By comparing the results from those who finished all the steps in the second study with the first study results, it is possible to see (Table 8) that the average duration used for each step has been reduced. The first time, it took students 21 minutes on average to complete step 1. The same group, however used an average of 20 minutes to finish the tasks during the second time practice. The average duration was 18 minutes for

completing the second step which has two tasks during first practice, while the participants took 6 minutes to complete the first task from the step 2 in the second study. 19 minutes on average were used for finishing the third step in the beginning, after which the practice time was reduced by 29% of the original duration for completing the last step.

Step	Average Duration	Number of failed students	Average Duration	Number of succeeding students
Step 1	67	2 (6%)	20	34 (94%)
Step 2	12	23 (64%)	6	13 (36%)
Step 3	16	10 (28%)	14	26 (72%)

Table 7. The average duration used for each step and the number of succeeding or failed students during the second study

Scenario A	First time with guideline (duration, in minutes)	Second time without guideline (duration, in minutes)	Time reduced
Step 1	21	20	5%
Step 2	18	6	67%
Step 3	19	14	29%

Table 8. The comparison of average duration between the first study and the second study

When the students were asked (Q2) *"Did you enjoy this EMR system more than the last one? Why and how is it better or worse?",* everyone answered that they like this EMRS rather than the previous EMRS that they have used. The main reason was they liked the interface (72%, n=26) of this EMRS, they also felt that OpenMRS is easier to be navigated (33%, n=12). 8 students (33%) said that the installation process is much quicker compared with the previous one. Conversely, there are 3 students (8%) who mentioned that the installation duration of OpenMRS is longer. Besides, some students mentioned that there are some errors in OpenMRS. For instance, some students (22%, n=8) said that the system cannot export or upload image, some students (11%, n=4) said that the doctor's visiting process doesn't really make sense and 17% (n=6) said that making an appointment for the patient is very difficult, as well as having difficulties modifying the patient data (8%, n=3).

To the last question (Q3) *"After solving the instructional units with the different EMR systems, what is your opinion on the features that a good EMR should have (except for other languages)?"* 56% (n=20) of the students suggested that a good EMR should have a user-friendly interface and help menu (28%, n=10). Providing a welcome page with some beginner tips or guideline is also mentioned by 22% (n=8) of students. Students also answered that keeping and managing medical records (17%, n=6) that can be easily be navigated in the system (17%, n=6) is also important. Five students wanted a system with their native language (14%, n=5) and a clear category of the menu bar (11%, n=4). Four of the students (11%) have mentioned that the medical process in the system should be built based on evidence. The medical data should be able to modify easily has been brought out by 8% of students (n=3), two students (6%) mentioned that a good EMRS should have a test result upload function, search function (6%, n=2), appointment management (3%, n=1), information of the status of the patient (3%, n=1), notification function (3%, n=1) and the possibility to create shortcuts for certain functions (3%, n=1).

7 Discussion and Conclusion

This thesis conducted two studies in order to collect information for the research questions; the first study is used for understanding the students' learning outcomes, feedback and learning objectives regarding the instructional unit. The second study is used for answering one research question from the introduction and evaluating some parts of the learning objectives. The results from chapter 6 will be used as an evidence to answer the research questions and reach the conclusion of the thesis. The limitations of the work were pointed out for future research purposes.

7.1 The discussion of two questionnaires results

In order to improve the instructional unit for the purpose of better education, this thesis conducted the first questionnaire to collect information, and the results of the questionnaire can be seen in the thesis section 6.1. As the Q3 results showed, the average duration was shorter in the last practice scenario compared with the first practice scenario. While answering Q4, some students also mentioned that the first practice was challenging for them. Uploading the test result was the most challenging task in the class which can be related to some students not knowing that there was a guideline for helping them with the practice. The language barrier was also brought by students and it can be seen in Q4, Q8, and Q11, which may cause the students misunderstand or not understand the guideline or the EMRS menu, which is why the practice may become much harder for the students who are not fluent in English, leaving them with less time to complete each task.

In reply to Q8, most of the students wanted to have a better interface for easier navigation in the system. This was better shown during the second study, where the OpenMRS was the students' favorite system due to its better interface, despite the OpenMRS has some system errors as well as more complicated visiting process for patient care and fewer functionalities compared with the OpenEMR, as shown by the answers to the questionnaire (Q2). This part pointed out that the user-friendly interface

is the most crucial criterion for the students (users). However, the system errors that occurred in the second EMRS is the main reason that caused the most of the students' inability to finish the second step, which showed the weakness of OpenMRS.

The students' opinions towards the instructional unit (Q7) proved that the PBL and the case study can give them the valuable experience through teamwork. The first eHealth software and simulated doctor's work experience was also appreciated by the students. The whole study is mainly done by students themselves with eLearning, PBL and the teamwork approach. The teacher only gave a short introduction in the beginning of the class and provided limited help which as required by the PBL. Therefore, the guideline with a detailed explanation of each task was the most valuable parts of the training unit from the students' point of view, since it can help them with the task completion. The characteristics of the teaching methods in the training unit were one reason that motivated the students to increase their efficiency and ability of self-learning. As Q8 and Q11 showed, the clearer instruction along with more pictures in the instructional unit, video tutorials and detailed tasks in guideline were brought out by the students. This may indicate that students were thinking the methods which could help them to improve their self-learning efficiency.

In the beginning of the class, many students believed that they have a poor computer using skills. From the answers of Q4, the most of the students thought EMRS installation process is the most challenging for them compared with other tasks, therefore, at question 11, besides the existing guideline as the assistance, they asked for more help with the EMRS installation process. The students' poor computer skills are one possible factor in being the reason that caused the problem in taking the screenshot, the screenshot was required in order to have better insight into students practice process. However, students wanted to have easier or better methods for taking the screenshots, or they would prefer to take fewer screenshots in general, which can be seen by answers to the Q8 and Q11.

From the first questionnaire, some students also pointed out that they want longer study time for this instructional unit while some of them thought that practicing three similar scenarios is not necessary since they believed that only practicing two scenarios is enough. All of the pointed out suggestions or problems that will be taken into consideration when the author modifies the instructional unit (Appendix 6). In the

second study, the second step was failed by most of the students since they tried to complete the task which was removed from the second study, due to the OpenMRS not supporting the upload test result function. The students also reported the reason of failing step two was due to the system error in the second questionnaire.

At the introduction chapter of this thesis, the author discussed that hospitals are struggling with training new employees to use hospital's EMRS. The author believes when the students have learned some practical knowledge of the EMRS in the school, future employers (hospitals or medical institutions) can expedite training process for the use of EMRS. Therefore, the second study of this thesis was conducted as seen in section 6.2. The comparison data is a strong evidence that shows the students can complete the same tasks from the scenario A with shorter duration despite not having any help or guideline for using the EMRS, as shown in the second study.

7.2 The comparison of other similar EMRS training units based on literature review

Compared with Stephens et al. (2011) study, the designed instructional unit in this thesis provides an overview and practice opportunity of the EMRS for undergraduate students, whose study field is related to healthcare technology. Basic computer skills and medical knowledge are enough for the students before attending the class. After completing the EMRS training unit, students would have the concept of basic functionalities in EMRS and would be able to perform some basic data entry and search in the EMRS. However, the further learning process for a higher clinical and patient development is not included, therefore, it presents a possibility to conduct a further study in order to develop a systematic approach for students' competencies at different stages of clinical development.

Jeanne E. Frenzel (2010) combined the patient-centered care with 12 different patient cases in the EMRS. It was a successful patient-centered care education that uses the EMRS and simulated patients for third-year students in a pharmaceutical care laboratory course. The instructional unit has different aim compared with Jeanne E. Frenzel (2010) study, since this thesis is less focused on medical knowledge enhancing or improving the patient care. Moreover, the overview and practical skills of using the EMRS is the

center of the whole instructional unit. However, the case study used in this thesis is for better understand the functionalities of the EMRS and in order to get the final results, the author of this thesis used rubrics as an assessment tool for final results.

In general, two pieces of literature were reviewed and compared and the common part of the literature is for using the EMRS as a teaching tool in order to gain and enhance medical competencies, which is also a good approach in order to facilitate the medical students with the knowledge and EMRS-specific skills. The RIME Scheme included all different level competencies during the whole study year. This is one part that the author of this thesis also mentioned in section 4.4, which is to have a systematic EMRS training unit in the curricula that also can provide a sustainable learning process in the EMRS. On the other hand, the instructional unit designed in this thesis has a simple approach and it is suitable for both beginners and more advanced students in the medical study. No matter if the students' study program is orientated to professional physicians or medical technicians, this training unit will briefly introduce them with the EMRS and give them actual practice within the EMRS.

7.3 Limitations

The target group is from a German university and they are all local students whose mother language is German. Also, their study program is in German, which means that some of them are not good at English. However, due to the study language for this thesis being in English and the author's poor German language skill, thus the instructional unit was designed in English, the EMRS that was used for conducting the studies also being in English. This was one of the difficulties for some of the students and they needed to spend extra time to understand the whole instructional unit and system. The author suggested that the native language should be used when possible since it can improve the students learning experience towards the whole class, achieving better learning outcome and more positive experience when using the EMRS.

Regarding the last question from the second questionnaire, the students pointed out many functions that a good EMRS should have, which was answered after two different EMRS practice experiences. For example, user-friendly interface, help menu, a welcome page with beginner guide, native language and easy navigation were answers that mentioned by students. These functions are proposed from the participants'

personal perspectives and experience. For instance, the most important function that the students brought out was a user-friendly and simple interface in OpenMRS, after they experienced the inconvenience and complicated interface from the OpenEMR, thus. they concluded that the interface has to be clear, simple and easy to navigate.

Most of the students had their own opinions of what kinds of functions that a good EMRS should have from their personal experience, which is one of the learning objectives of this thesis, it is possible to know that students have completed this learning objective from the results of Q3 in the second study. However, the author still believes that a good conclusion and opinion should come out after considering multiple criteria, such as literature review, feedback from the real users (doctors, nurses), system designers or anyone else who has used the EMRS for their work. Therefore, a better and more realistic model of a good EMRS will be established after taking multiple factors and perspectives into consideration. However, these kinds of competencies cannot be achieved in a 90 minutes training session from the instructional unit in this thesis. Regardless, it is still important to keep in mind that maintaining students' openness towards the EMRS functionalities is important.

As the Jay B et al. (2009) included a control and intervention groups in their study and compared the results from these two groups [73]. The original plan of the thesis author was to conduct the second study with a control group as well. However, due to the limited resources, this thesis did not have the chance to find a control group for the second study. The comparison data was made from the same group during the first study and the second study. The results showed that the improvement of the practical skills in the study group and the positive effects of the instructional unit. Nevertheless, the interface of the EMRS, along with the installation process, practice date, the students' attitude toward study in general as well as many other possible factors can affect the final results. Therefore, it is recommended to have a control group in the study for a better insight of learning outcome.

7.4 Conclusion

As mentioned in the introduction chapter, the medical education has not paid enough effort to educate medical students with the EMRS practical skill, while the EMRS has already been adopted by many medical institutions, with the number of adoptions

raising year by year [66]. The need for the EMRS practical competence is equally important as the students' medical knowledge. Therefore, the redesign of the curricula to meet the students' needs is required since they are living in the digitalized world which means they will most likely come into contact with EMRS in their future career. The created instructional unit is mainly focused on the practical skills rather than the theoretical knowledge. Furthermore, the EMRS education can also benefit future employers of the students. If the curriculum is much closer to the actual work practice, then the employer can spend less time and resources on the new employees EMRS training process. The students who have EMRS training in their school will also feel more confident with their future work and adapt to new working environment faster.

In order to have an EMRS for the instructional unit practice, the author selected OpenEMR as the system. However, the chosen system is not the perfect one. For instance, students have the negative reaction to the EMRS installation due to the difficulties occurred during the process. This problem could be solved by pre-installing the EMRS in the school's computers by IT specialist before the start of the class. In addition, if the installation manuals would provide a clear explanation of the process and the answers to all common problems that could occur, then it could potentially improve students' first-time user experience with the EMRS. Moreover, there are also some other Open Source EMRS that can be used as a teaching tool. It will depend on the diverse needs from the potential users according to the teaching goals and the participants' backgrounds. For example, the language barrier could be removed for German students if the EMRS is in the German language, while French-speaking students could use the system in the French language. An EMRS with laboratory functions would be a crucial point for the students whose major is the radiology, while cardiology students may not use this function at all. Thus, there is no perfect EMRS for meeting all demands of the potential students. This means that the selecting criteria should be customized according to the users' requirements, background and learning objectives.

The average duration of the first study has shown that repeating the practices made students complete the tasks faster. The performance competency has a positive correlation with the practice frequency; moreover, the sufficient practice has direct benefits of the learning objectives. However, the students tend to prefer easier or less

demanding tasks due to the human nature. This can be seen from the feedback that the students have provided, mentioning the study duration issue. Therefore, the length and intensity of the study should be decided cautiously in order to achieve the learning goals.

From the conduction of the two studies, the comparison result from table 8 revealed that the instructional unit helped the students with an ability to adapt a new EMRS designed by the different companies. In general, the learning objectives are achieved from this instructional unit. However, the learning process turned out to be a bit challenging for the target group. The reasons can be unfamiliarity with the system in the beginning, lacking medical knowledge and the difficulties to understand the language. On the other hand, building an instructional unit is not only done for achieving learning objectives and goals, but also bringing the students a pleasant learning experience and an efficient learning process as well.

eLearning is one of the teaching methods that is used in this instructional unit, and the students use the EMRS as a digital tool to learn physicians or nurses daily work. The materials used for this class are all available in a digitalized form and they are shared with the students via university study portal. The teacher needs to teach less and act as a tutor role according to PBL method, since the whole study process is a self-driven process by the learner. At the end of the class, students also suggested providing video tutorials or more detailed materials in order to improve self-learning efficiency. This brought the possibility to conduct an online course where the teacher's teaching part can be recorded in a video form and uploaded in the study port, after that designing a detailed study process with screenshots or pictures as well as words description for better understanding, while providing a digital assistance for the students through the e-platform. Additionally, the students still work with their peers as a team. However, it will not be necessary for them to meet their team members in a physical location since they can communicate with each other through the digital tools, like Skype or Facebook. The security will always be the first priority that is to be considered in the digital world, but with thoroughly security check and legislation, this will not be an obstacle for applying the eLearning method. The complete eLearning method gives more flexibility and opportunity for students to meet different students from other study programs, while allowing them to have a more flexible schedule and location options.

The future study of EMRS education could engage more stakeholders, as the results showed, the students are interested in an actual doctor's or nurse's daily practice with the EMRS: how the professionals from different departments interact with each other in the system, what are the benefits, what are the advantages or challenges they face when they use the EMRS. With these real-life experiences, the students could understand their future work more thoroughly and readjust their learning objectives or orientations for the further studies if that would be necessary. Meanwhile, the integration of the EMRS with smart tablets or smartphones would be an attractive direction according to the teaching goals. The students can be the users or designers of this digital system. The knowledge they learned in the school is the foundation of their further researches. The theoretical knowledge can be examined during the usage of the practical skill. This learning experience could be their first step on their path to professionalism.

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Appendices

Appendix 1 – Instructional unit

Subject: EMR systems

1. Learning goals

- Students learn to use EMR systems
    - Register new patient in the system
    - Search for a patient in the system
    - Schedule an appointment for the patient
    - Write medical a note in the system
    - Write diagnosis in the system
    - Write diagnosis in the system
    - Order examination for the patient in the system
    - Upload test result in the system
    - Write nursing care plan in the system
- Students can use EMR system to practice patient care after this instructional unit

2. Group size

- 3-5 students

3. Length

- 3 x 45 minutes, in total 3 classes

4. Prerequisites

- Each group has at least one computer with OpenEMR system installed
- Students have adequate medical background to practice different scenarios
- Teacher needs to register different user accounts in the system for each group before the lecture starts

5. Procedures

- Students read the general instructional material
- The teacher gives a short introduction about the EMR system and then demonstrates how to use EMR system in the first class.
- Students follow the tasks as described in the instructional material.
- Form 3-5 persons in one group, with 3-6 groups is the best result.
- Assign different roles (doctor, nurse and patient) to each group member, assign rest students as the nurse if there are more than 3 people in one group.
- Randomly select scenario for each group.
- Practice scenario tasks with teacher's assistances at second class.
- Last class, switch scenarios with different groups, also switch roles for group members and practice once more.
- Students grade each other with grading criteria, create a random name list of students, the first person in the list grades the second person, the second person grades the third person and so on. The last person grade the first person in the list.
- At the end of class, students fill out the questionnaire.

Electronic medical records system (EMR system)

An Electronic Medical Records (EMR) is designed to save medical paper records or charts in digital form, it includes patient's personal information such as name, age, address, contact information, insurance or billing information, it also has patient's medical history, laboratory test, radiology images, medication, allergies and so on; There are some basic functions that are used by all different EMR systems. For instance, basic personal information and medical note history. there are also some different advanced or customized functions that exist in a different system, for example, some EMR systems have an online booking from the patient portal, while others might not support this function.

EMR systems help healthcare sectors to manage their services much easier, such as diagnosis, treatment, appointment management, tracking inpatient and outpatient information, scheduling appointments, operations or beds wisely. Patients only need to bring their identification card to visit the doctor. The doctor can view patient's medical history over a long period of time from the computer, which helps the doctor to make faster and more accurate diagnosis. At the same time, the doctor or nurse can monitor patients' treatment results. If the patient has preventive checkups or an upcoming appointment, EMR system can also send a reminding Email or SMS to them. EMR system is designed to help organizations provide efficient and precise care for patients, improving general health care quality.

Compared with traditional paper records, digital form data gives simple access, saving doctor's time from going through many different paper records. EMR system requires data to be stored accurately and legibly; only those who have been granted to have access to data can view them. Meanwhile, each access activities can be monitored and recorded. Although many useful data are collected and classified, it is also possible to share it among health care providers under patient's authorization and regulations. However, sometimes exchanging the data can be very difficult when the data is formatted differently. In the future, these collected data can be used for providing better health care services for society, such as using epidemiology study to help the government provide a better insurance plan for its citizens.

From EMR system patient's portal, patients can access their medical data online with no time or location limitation. Therefore, they can bring their medical records with them no matter which health care provider they visit. For instance, they can print their medical records online and bring it with them when they visit another doctor. In the future, it will be possible that the patients have one integrated medical record that is provided by multiple health care providers.

Meanwhile, family members can also access patient's medical records from patient's portal under the authorization; they can view clinical summaries, laboratory tests, upcoming appointments, screening alerts or related medical care advice. It is also possible to engage family members with patients through the whole treatment process, for example, the family members can read related medical articles or videos from the portal, understanding better about the treatment plan and matters that need to be careful. Therefore, family members can provide better support for the patient.

Case study

The case study will use OpenEMR System as practice system. First of all, install OpenEMR system in the computer, the installation instructions can be found in this link http://www.open-emr.org/wiki/index.php/OpenEMR_Installation_Guides; After successfully installed system, the instructor should create new accounts for students to practice case study. There are total three scenarios, each scenario has three steps with several tasks listed.

Scenario 1

A man with chest pain

Patient 1: A married male named Shepard Smith, born on 1st Jun 1957, ID code is 08570601, he lives at Frankensteiner Straße 20, 60594 Frankfurt, Germany. His body weight is 80 Kg and Height is 188cm.

This morning Shepard presents to the local hospital complaining his chest pain. He said to the doctor: "Doctor, my chest, it's still hurting. What's going on?" His pain is in the middle of his chest that suddenly abrupt an hour ago whilst he was watching TV at home. It felt like there is an elephant sitting on his chest, he had a tingling feeling in his neck and jaw, but that's gone now. He felt really nauseated and vomited once before came to the hospital. He does feel a little shortage of breath which he has never had

before. The pain isn't affected by his position or by taking deep breaths. The pain has gone down but it's still noticeable and feels heavy, and it was 8/10 at the start and about 5/10 now.

In his past medical history, he never had chest pain like this before, although he has a few niggles every few months, nothing like this over last few years. He didn't visit a doctor about the niggles, and he has never been diagnosed as having any heart problems. He has high blood pressure and cholesterol, and he takes tablets for those. Shepard smokes 20 cigarettes per day for the last 30 years, but he doesn't drink and do regular exercise.

Task:

In order to give direct insight for the teacher to understand the process of practice, there are two matters need to be followed;

1) Write the patient's name with group name as the family name when registering a new patient in the system such as Shepard Smith Group1.

2) Please keep a screenshot of each step from the computer, and document them in a word file in the same order as the steps.

Step 1 (15 minutes)

1. Please register this patient in the system as a new patient.

2. Gather important information from the article above, find the complaint, symptoms and other findings. Keep notes in the system about this patient's medical or nursing history and current symptoms.

3. Make a preliminary diagnosis and write it down in the system.

4. Schedule an appointment for patient's next visit in the system.

Step 2 (10 minutes)

1. Search for the patient in the system, export his medical and nursing records.

2. Order examinations for the patient through the system according to your preliminary diagnosis, including three types of evaluations (BP, pulse, respiration), upload test result in the system.

Step 3 (15 minutes)

1. According to lab test give a further diagnosis and add it into the medical note.

2. Make a nursing care plan in the system for the patients according to the collected information.

3. Write a follow-up plan in the system, schedule next visit or monthly/annual check-up.

Scenario 2

A lady with trouble sleeping

Patient 2: A 46-year-old single woman, born on 1 Dec, 1970, ID code is 08701201. Her name is Jane, she came to her GP as she has been feeling unwell over the last few months and things appear to be getting worse, she lives in Amsinckstrasse 39, 20097 Hamburg, Germany. Her body weight is 68 Kg and height is 168 cm.

Jane complained that she is not feeling well, she feels terrible and struggles to sleep. She lost 8kg over last 6 months. Sometimes her heart is racing and she believes something is seriously wrong with her. Her appetite has been fine and works out regularly, she has been going to the gym twice a week for many years.

Lately, Jane has diarrhea, happens about 3 to 4 times a day, normally she only goes once in the morning. Diarrhea started about 4 months ago and hasn't improved since. There is no change in the color and no blood in the stool. Unidentified trigger, regarding no matter what she eats or does, no abdominal pain or bloating.

Jane is afraid of having a heart attack from heart racing. It comes on suddenly at random intervals, she can't identify any triggers. No chest pain or shortness of breath, but sometimes feels a bit dizzy. Although she has never experienced losing consciousness.

Jane mentioned that she has been feeling a bit shaky, hands tremble at times. Generally, she is fairly fit and well, no other medical problems and no any regular medications, but she takes oral the contraceptive pill.

Task:

In order to give direct insight for the teacher to understand the process of practice, there are two matters need to be followed;

1) Write the patient's name with group name as the family name when registering a new patient in the system such as Shepard Smith Group1.

2) Please keep a screenshot of each step from the computer, and document them in a word file in the same order as the steps.

Step 1 (15 minutes)

1. Please register this patient in the system as a new patient.

2. Gather important information from the article above, find the complaint, symptoms and other findings. Keep notes in the system about patient's medical/nursing history and current symptoms.

3. Make a preliminary diagnosis and write it down in the system.

4. Schedule an appointment for patient's next visit in the system.

Step 2 (10 minutes)

1. Search for the patient in the system, export her medical and nursing records.

2. Order examinations for the patient through the system according to your preliminary diagnosis, including three types of evaluations (BP, pulse, respiration), upload test result in the system.

Step 3 (15 minutes)

1. According to lab test give a further diagnosis and write it into the medical note.

2. Make a nursing care plan for the patients in the system according to the collected information.

3. Make a follow-up plan in the system, schedule next visit or monthly/annual check-up.

Scenario 3

A gentleman with back pain

Patient 3: A 50-year-old gentleman called Karl, born on 29 Oct, 1967, ID code is 08671029, he presents to his GP with back pain, he comes from Goethestrasse 15, 80336 Munich and lives in Berlin. His body weight is 88 Kg and height is 186cm.

Karl had really awful back pain when he was lifting a TV out of his car, it began as soon as he lifted the television in the morning, he felt a click as it started. It becomes a constant ache and then sharp pain whenever he tries to bend. The pain is in the lower back and it does not shoot down the leg, paracetamol (a drug used to reduce pain which doesn't contain aspirin), ibuprofen (a medicine that reduces pain, inflammation and fever) and a heat pack helped him a little bit, he has chronic joint aches but nothing ever this bad. No noticed weakness or numbness and didn't have any issue to opened his bowels or passing water today. No noticed weight loss, fevers or sweats. The pain is stronger when he bends, paracetamol and lying help him a little, the pain is about 8/10 at its worst time.

Karl has high blood pressure and on Ramipril (a medicine) for it, otherwise, he is fit and well. He lives with his wife in a flat, neither of them smokes or drinks, he works as a lorry driver and hasn't traveled anywhere in years.

Task:

In order to give direct insight for the teacher to understand the process of practice, there are two matters need to be followed;

1) Write the patient's name with group name as the family name when registering a new patient in the system such as Shepard Smith Group1.

2) Please keep a screenshot of each step from the computer, and document them in a word file in the same order as the steps.

Step 1 (15 minutes)

1. Please register this patient in the system as a new patient.

2. Gather important information from the article above, find the complaint, symptoms and other findings. Keep notes in the system about patient's medical/nursing history and current symptoms.

3. Make a preliminary diagnosis and write it down in the system.

4. Schedule an appointment for patient's next visit in the system.

Step 2 (10 minutes)

1. Search for the patient in the system, export his medical and nursing records.

2. According to your preliminary diagnosis order examinations for the patient through the system, including three types of evaluations (BP, pulse, respiration), then upload test result into the system.

Step 3 (15 minutes)

1. According to lab test give a further diagnosis and write it into the medical note.

2. Make a nursing care plan for the patients in the system according to the collected information.

3. Make a follow-up plan in the system, schedule next visit or monthly/annual check-up.

Appendix 2 – Guideline for practice EMRS

Roles: Doctor, Nurse, Patient.

First of all, install system in the computer, instructions as this link http://www.open-emr.org/wiki/index.php/OpenEMR_Installation_Guides;

Now start to log in as administrator, and use this account to create a new account for practice(Fig.1).

Click "Add User" and it will pop out register new user window(Fig.2), create nurse account name as Nurse, and access control as "Front office". Create doctor access control as "Physicians" (Fig.3).

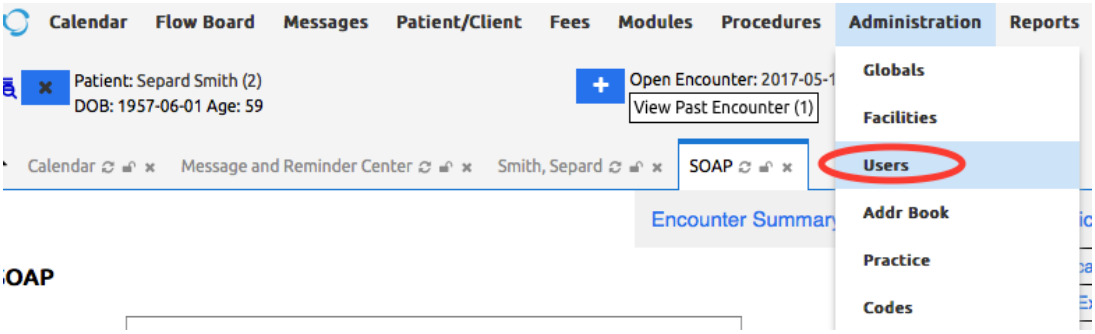


Fig.1

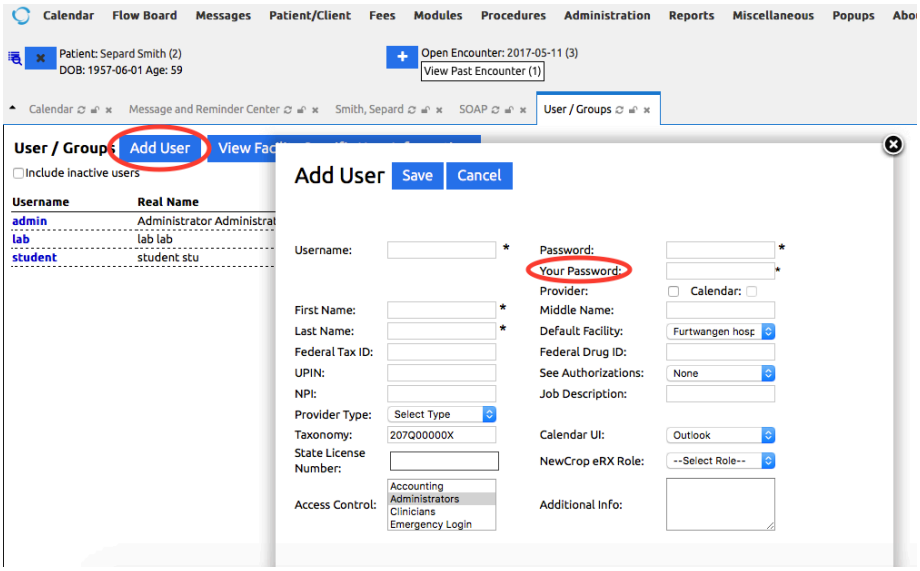


Fig.2

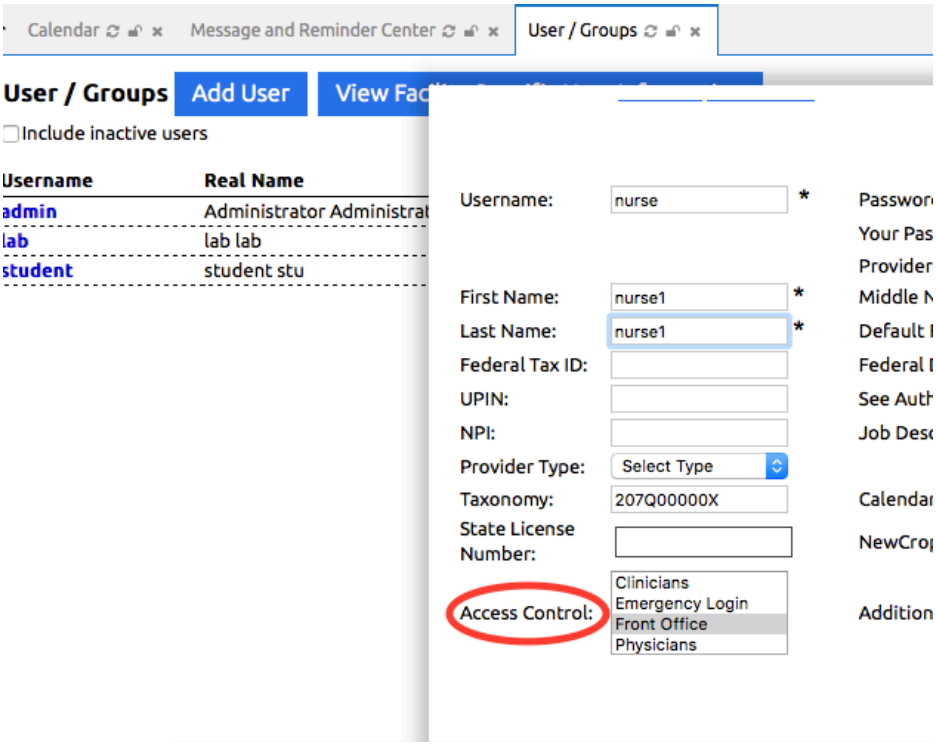


Fig.3

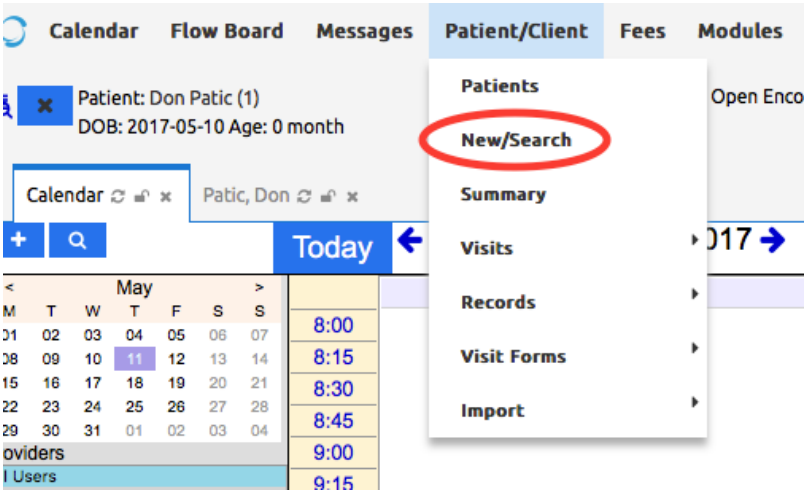
Form team at beginning of lecture, it's better to have three or six teams in total and 3-5 people in each team, then choose a role for each team member, such as doctor, nurse or patient. Randomly select scenario for each team. The course is better to teach in three classes, the first class contains two parts, the first half lecture is EMR system introduction, the second class will be scenario tasks practice. In the last class, switch scenarios with a different team, switch roles inside the team and practice more. At the end of last class, pass the questionnaire to students and collect feedback.

Introduction of EMR system

Brief introduction of an electronic medical records system uses digital way to keep patients' records, it's a tool used by health care provider to write their diagnosis and treatment.

The first step including 4 tasks as following;

Create a new patient, find “Patient/Client” at the top and then “new/search”, insert patient information and click save. Sample example is Patic Don as a patient.

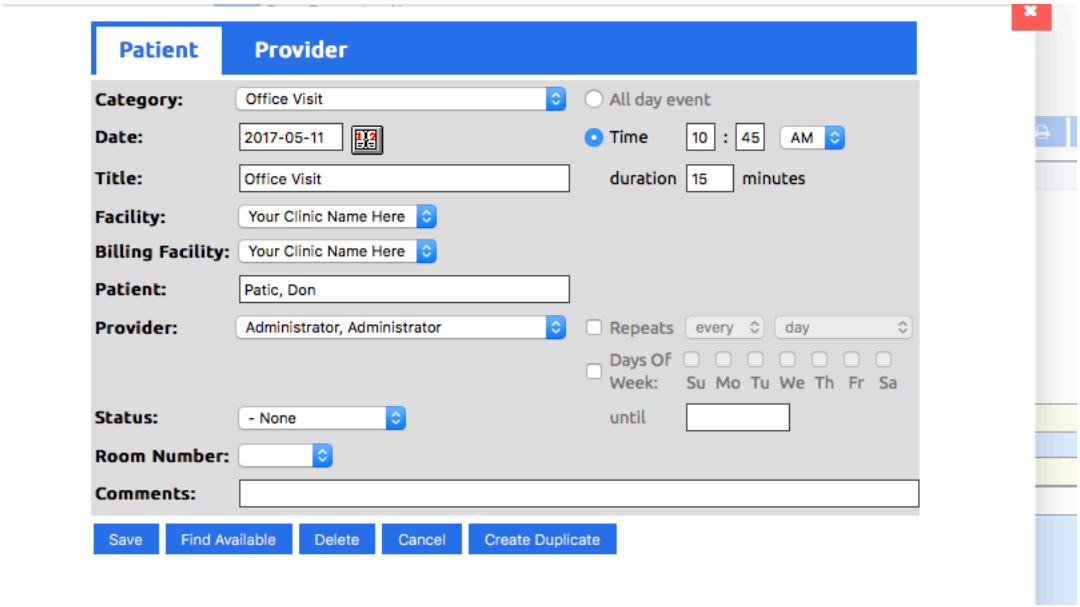


Search the patient you create, the same method as above, type “don”, click search.

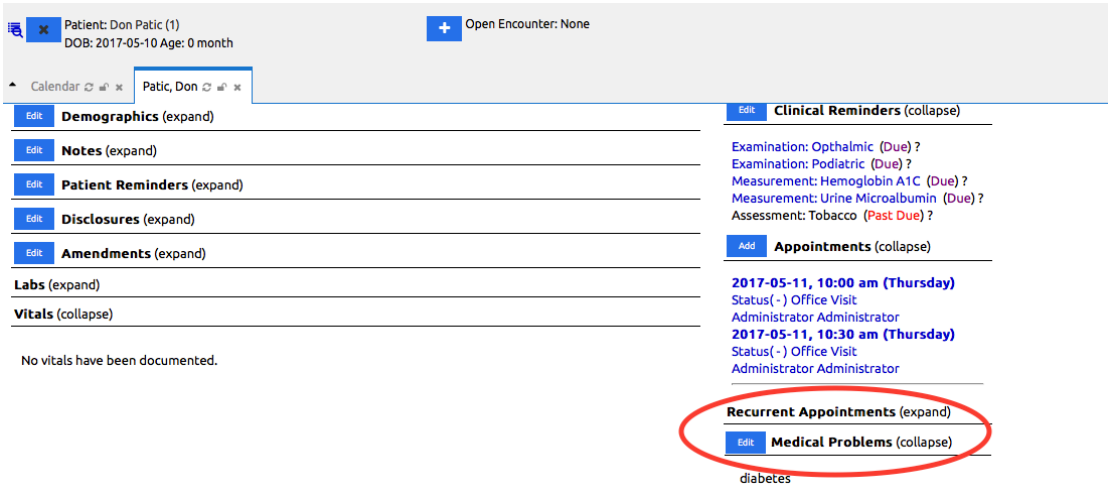
Making an appointment for Patic Don, go to the “Calendar” and select the date and suitable time, click on it then pop up a window, fill detail information there and click save.

It’s better to fill “Provider” schedule before making the appointment for the patient.

Try to add more schedules and practice to delete it as well, or change schedule time.



Search the patient you just added into the system and add medical problem for the patient.



Now introduce my approach to the scenario, I took scenario 1 as an example.

A man with chest pain

Patient 1: A married male named Shepard Smith, born on 1st Jun 1957, ID code is 08570601, he lives at Frankensteiner Straße 20, 60594 Frankfurt, Germany. His body weight is 80 Kg and Height is 188cm.

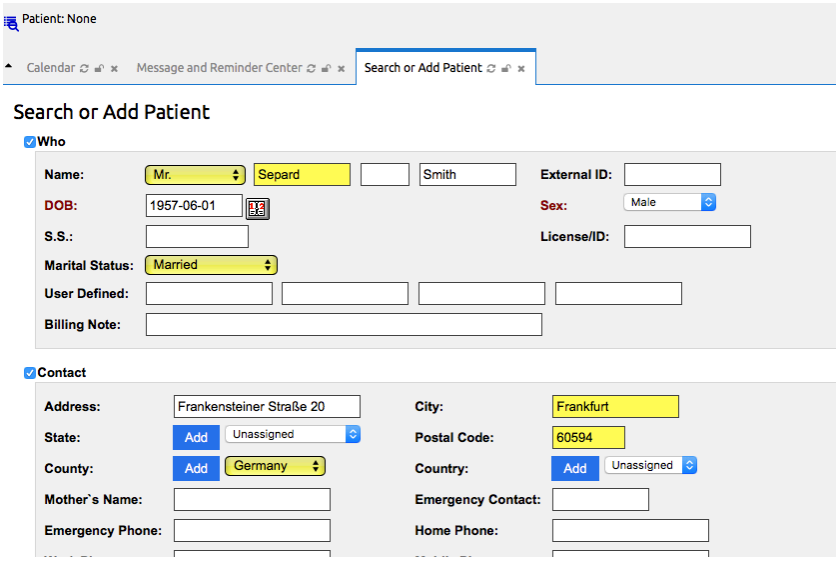
This morning Shepard presents to the local hospital complaining his chest pain. He said to the doctor: “Doctor, my chest, it’s still hurting. What’s going on?” His pain is in the middle of his chest that suddenly abrupt an hour ago whilst he was watching TV at home. It felt like there is an elephant sitting on his chest, he had a tingling feeling in his neck and jaw, but that’s gone now. He felt really nauseated and vomited once before came to the hospital. He does feel a little shortage of breath which he has never had before. The pain isn’t affected by his position or by taking deep breaths. The pain has gone down but it’s still noticeable and feels heavy, and it was 8/10 at the start and about 5/10 now.

In his past medical history, he never had chest pain like this before, although he has a few niggles every few months, nothing like this over last few years. He did not visit a doctor about the niggles, and he has never been diagnosed as having any heart problems. He has high blood pressure and cholesterol, and he takes tablets for those. Shepard smokes 20 cigarettes per day for the last 30 years, but he doesn't drink and do regular exercise.

Step1

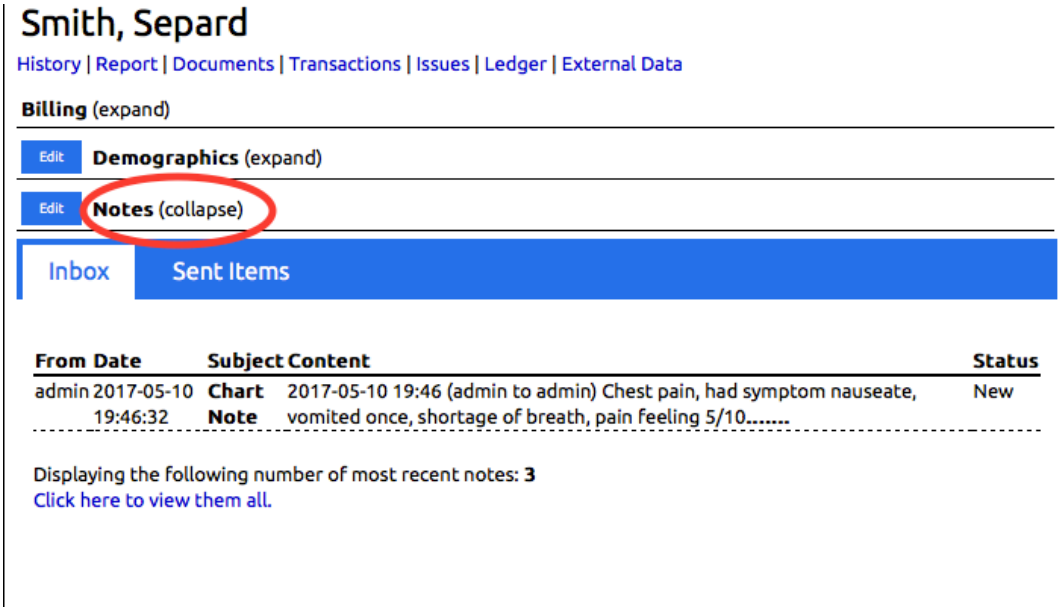
Register this patient in the system as a new patient.

Click "Create new patient" and "save".

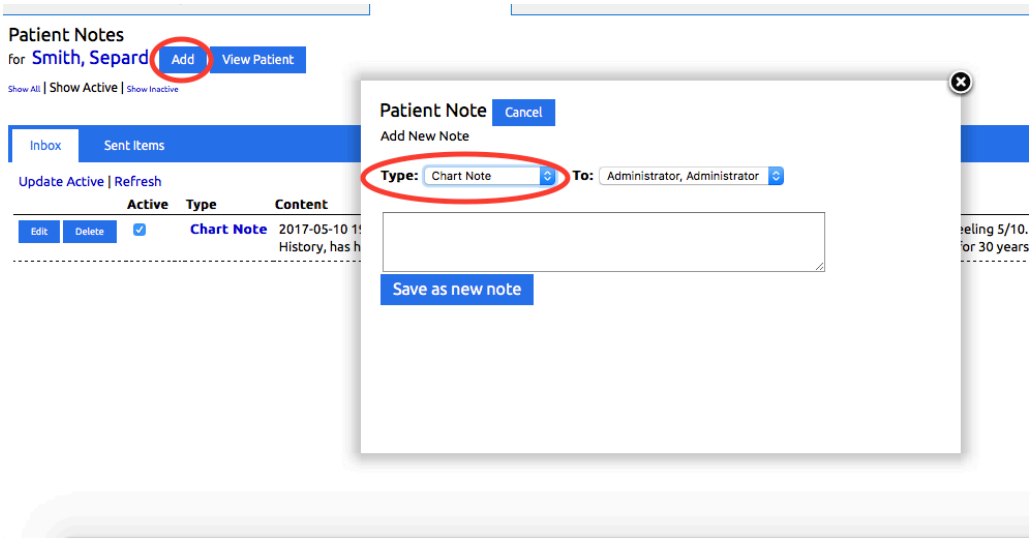


Gather important information from the article above, find the complaint, symptoms and other findings. Keep notes in the system about this patient's medical or nursing history and current symptoms.

Click on the patient, and click "Edit" button before "Notes", as the picture below.

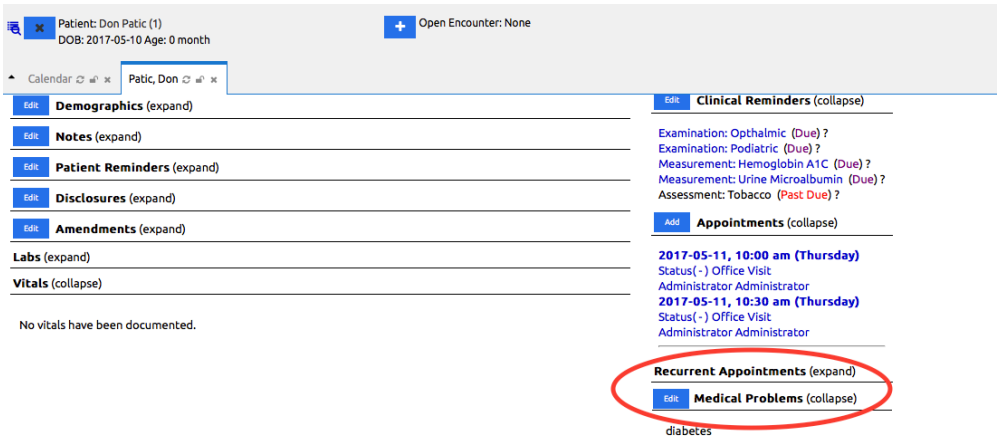


Click “Add” button, and choose “Type” of note as chart note. It provides different types, choose according to your needs. After writing the note, click “Save as new note”.

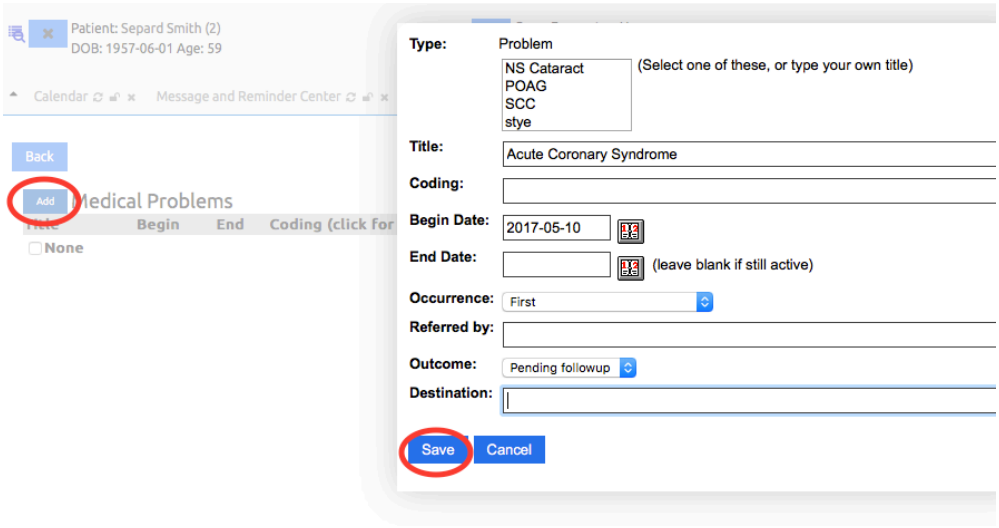


Make a preliminary diagnosis and write it down in the system.

Click “Edit” button from Medical Problems.

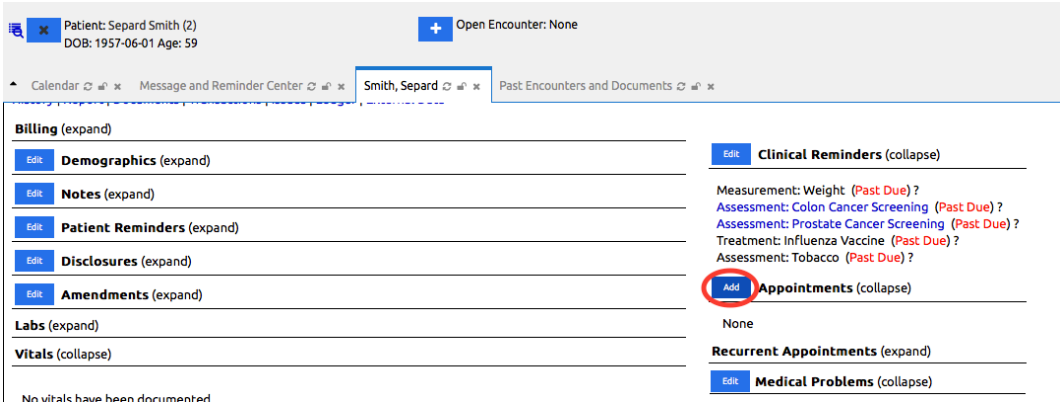


Click “Add” button to add diagnosis, and save it.

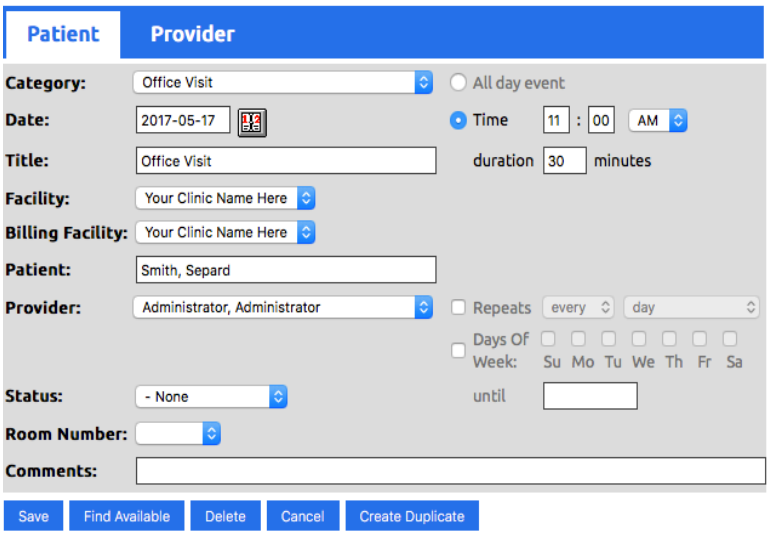


Schedule an appointment for patient’s next visit in the system.

Click “Add” button at “Appointments”.



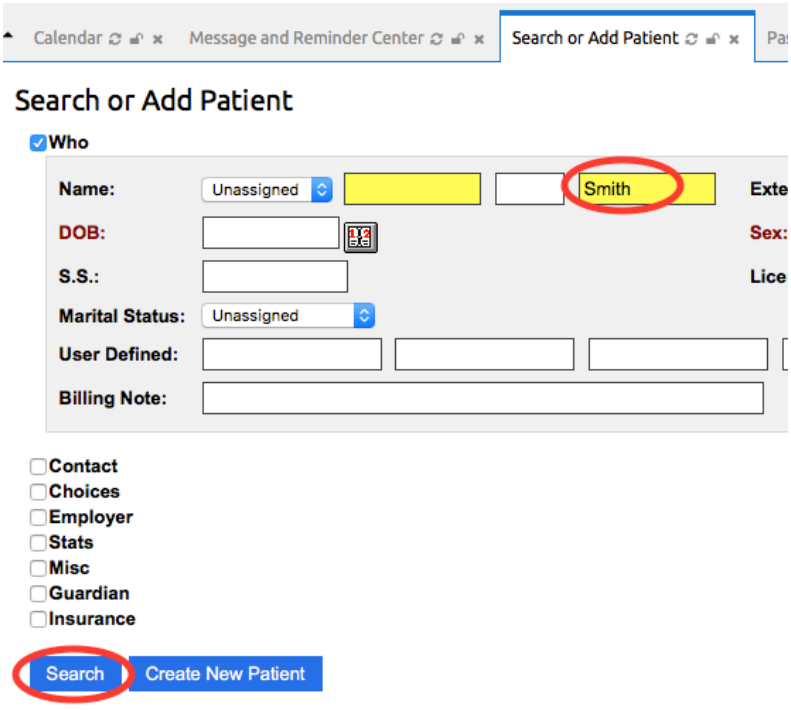
Edit next appointment time and click save.



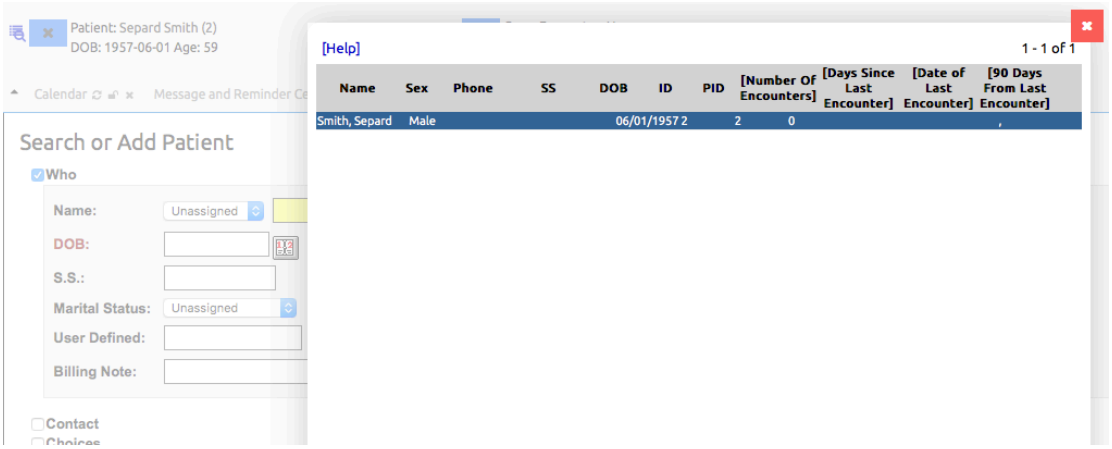
Step 2

Search for the patient in the system, export his medical and nursing records.

Click Patient/Client—new/search, and input “Smith”, click “Search” button.

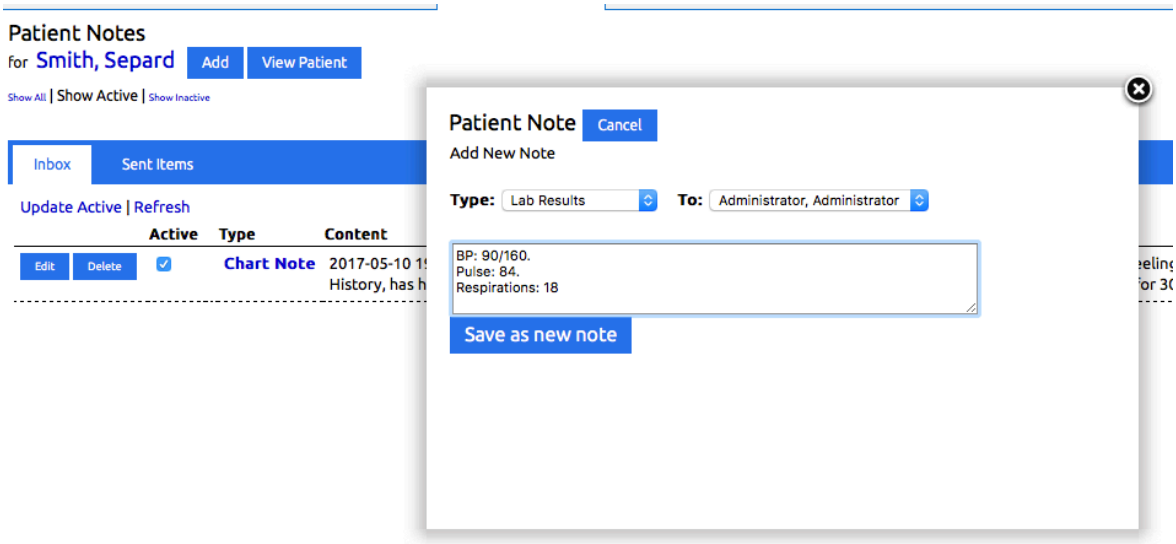


The system pops out a window and then chooses the correct one.

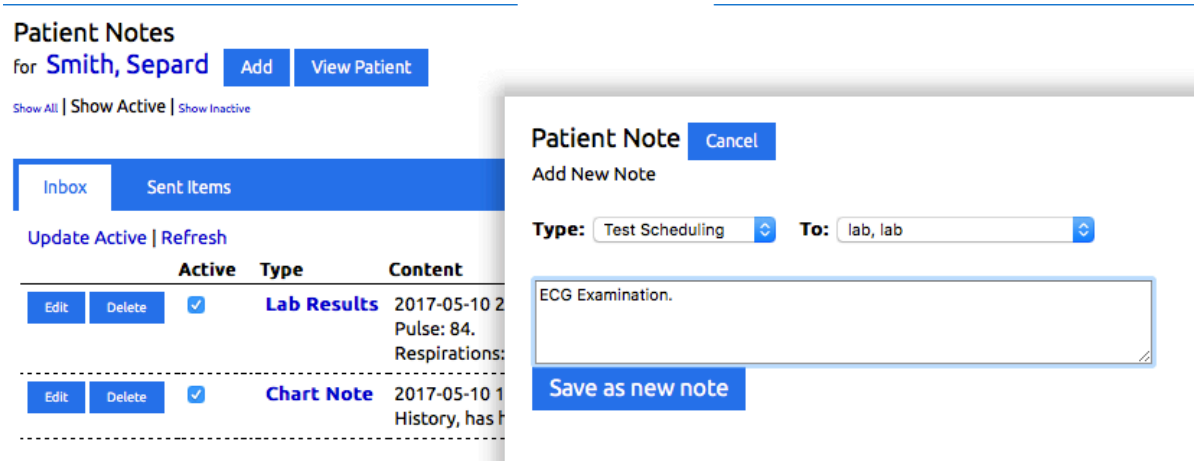


Order examinations for the patient through the system according to your preliminary diagnosis, including three types of evaluations (BP, pulse, respiration), upload test result in the system.

Using notes function, and choose note type as Lab Results.



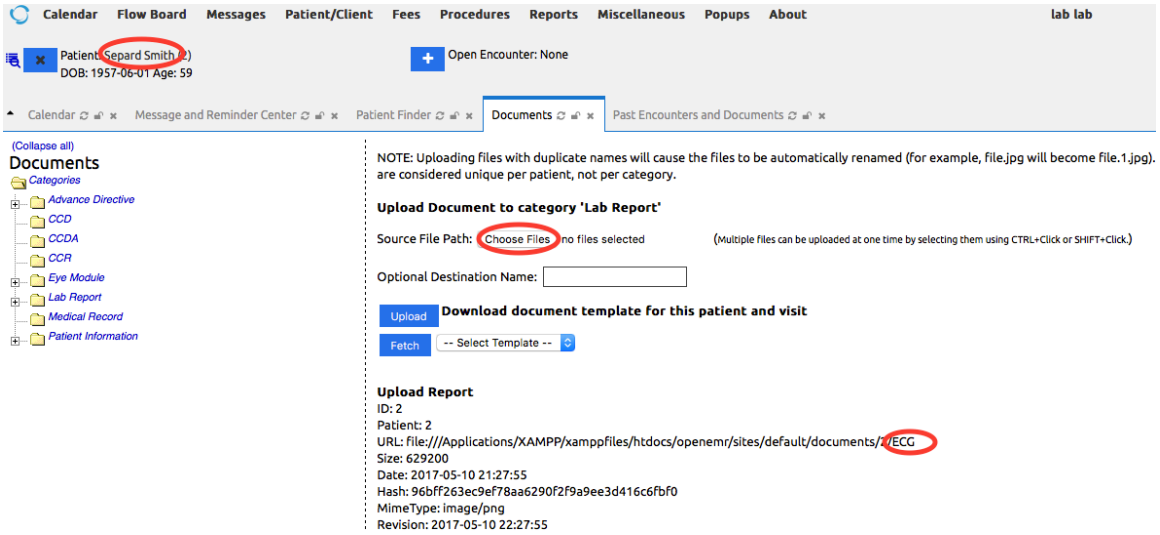
Order an examination for the patient, using notes function. Type: Test scheduling, to Lab.



Upload test result, two methods;

Use the same user to edit upload files.

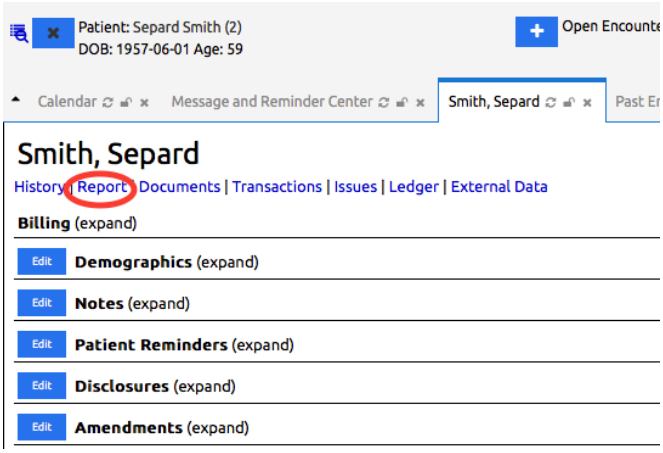
Use laboratory user name login, it will show one email at right corner, click letter will show the test order, then laboratory professions can upload the test result into the patient file.



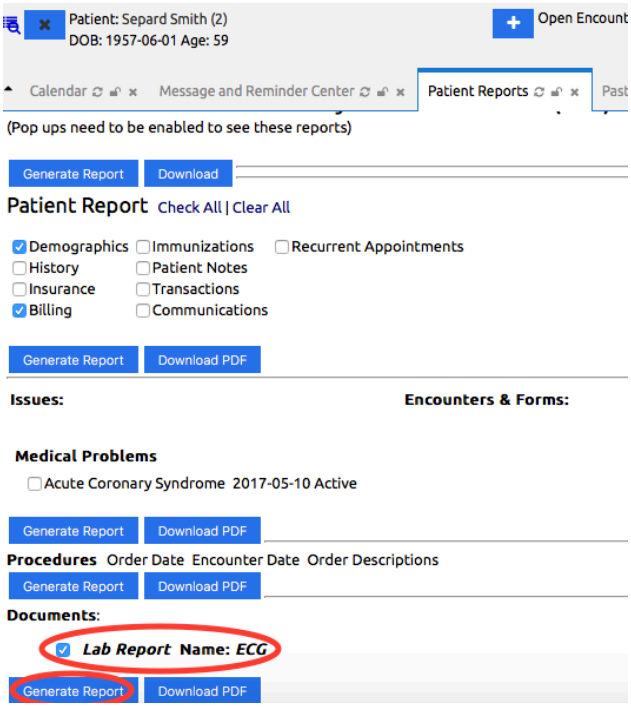
Step 3

According to lab test give a further diagnosis and add it into the medical note.

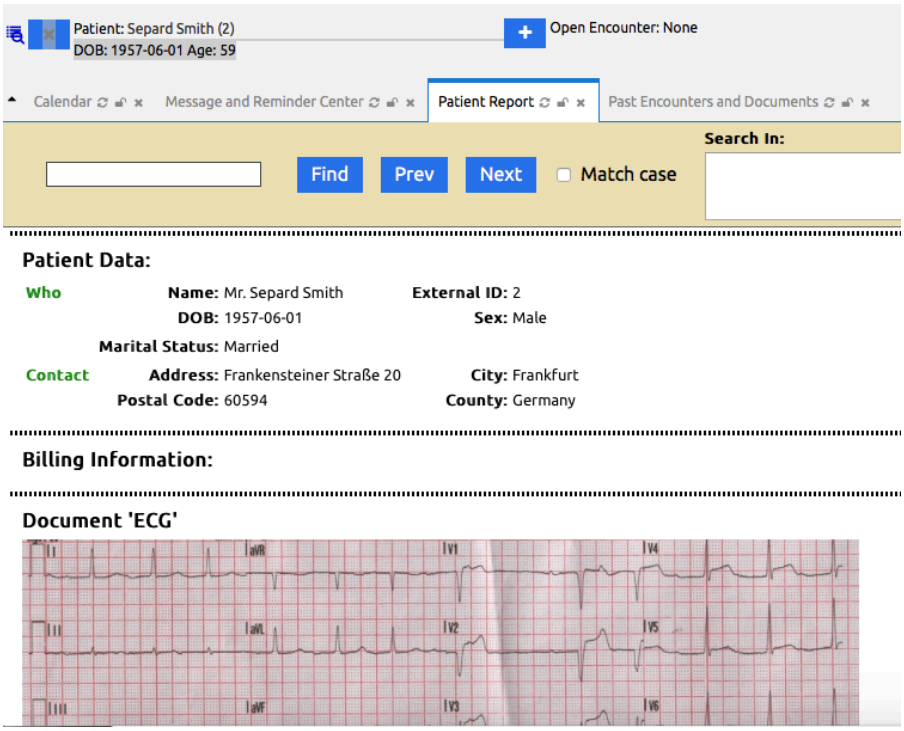
Review laboratory test by using “Report” function.



Choose lab Report and create a report.



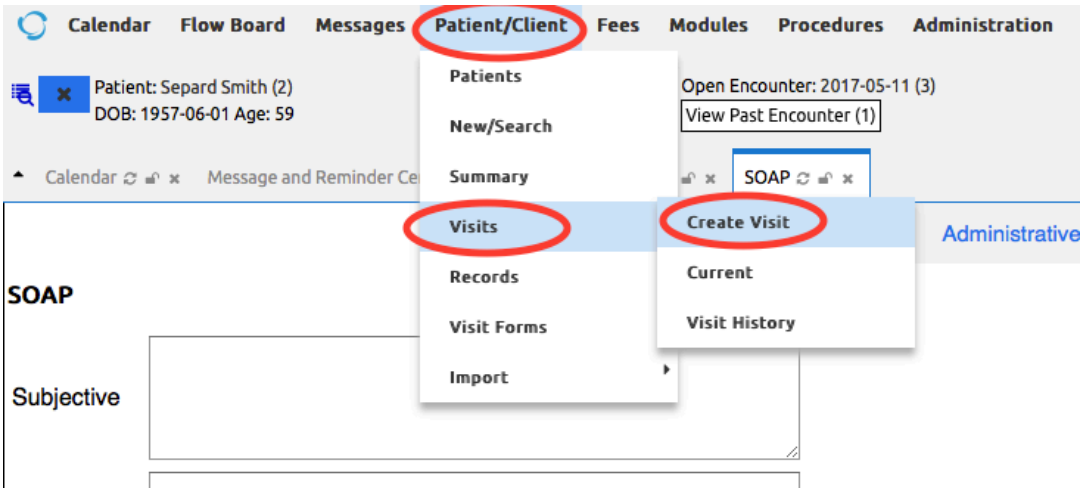
It will show the report as follow.



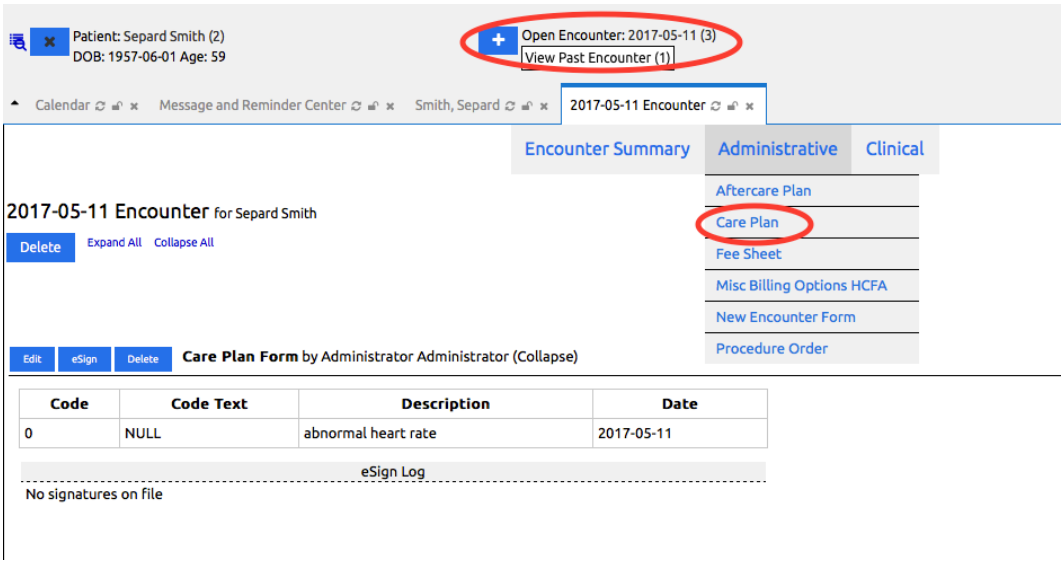
Edit new diagnosis, process same as step 1, 3.

According to the collected information, making a nursing care plan for the patient in the system.

Create a visit for the patient, as follows:

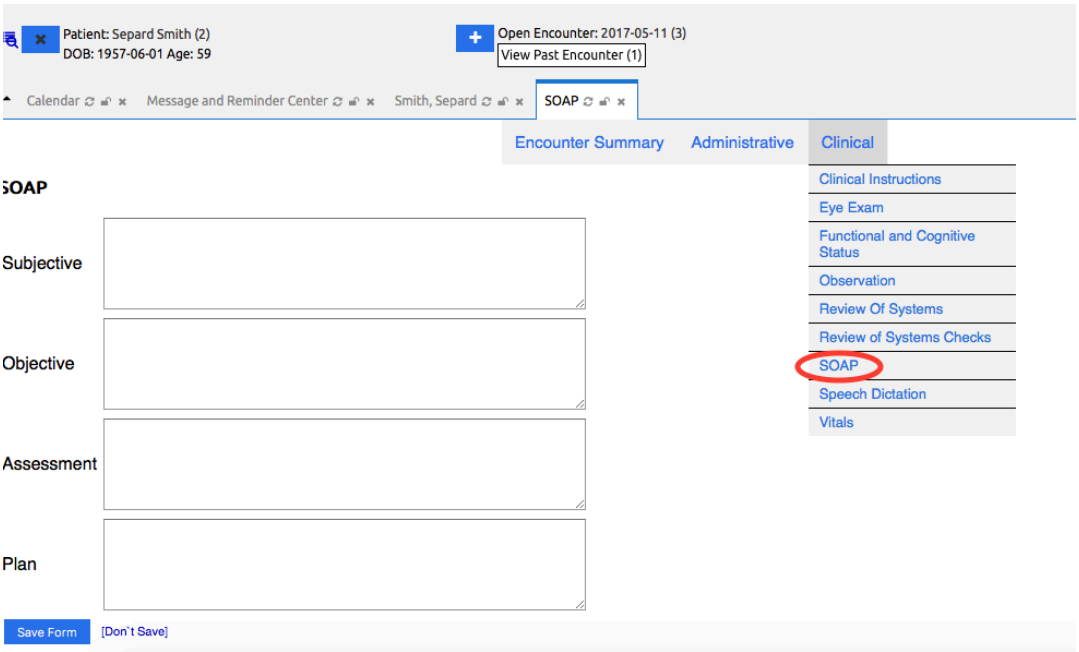


At this interface, use “Administrative” to “Care plan” function. Filling the form and save the plan.



Write a follow-up plan in the system, schedule next visit or monthly/annual check-up.

At visiting interface as above, use “Clinical” to “SOAP” to write medical notes to create follow up plan. Schedule next check-up same as Step1,4.



Appendix 3 – Questionnaire for the EMRS instructional unit

Questionnaire for the EMR system instructional unit

Name: Gender: Age: Studies: Semester:

1. How do you consider your computer / IT skills (please mark with a cross)?
   - ☐ Excellent
   - ☐ Good
   - ☐ Poor
   - ☐ Unacceptable

2. Have you used EMR systems before this class (e.g. at a doctor's practice or hospital reception)? If possible, please also specify location and time frame.

3. How long did it take for you to complete each task (Please fill in the time needed)?
   - ✓ Scenario 1
     - Step 1: ___ minutes; Why? (any problems?): _____
     - Step 2: ___ minutes; Why? (any problems?): _____
     - Step 3: ___ minutes; Why? (any problems?): _____
   - ✓ Scenario 2
     - Step 1: ___ minutes; Why? (any problems?): _____
     - Step 2: ___ minutes; Why? (any problems?): _____
     - Step 3: ___ minutes; Why? (any problems?): _____
   - ✓ Scenario 3
     - Step 1: ___ minutes; Why? (any problems?): _____
     - Step 2: ___ minutes; Why? (any problems?): _____
     - Step 3: ___ minutes; Why? (any problems?): _____

4. Which task was the most challenging for you in the instructional unit? Please explain the reason.

5. Was the provided background information sufficient to work on the instructional unit and were the task-related instructions clear at the beginning of the class (please mark with a cross)?
    - ☐ Excellent
    - ☐ Good
    - ☐ Poor
    - ☐ Unacceptable

6. Do you think this instructional unit is generally well structured (please mark with a cross)?
    - ☐ Excellent
    - ☐ Good
    - ☐ Poor
    - ☐ Unacceptable

7. What did you find valuable / positive in this instructional unit?

8. What would you change / improve in this instructional unit?

9. Do you think that you know how to generally use EMR systems after finishing this instructional unit (please mark with a cross)?
    - ☐ Excellent
    - ☐ Good
    - ☐ Poor
    - ☐ Unacceptable

10. What would you like to additionally learn about EMR systems besides what has been taught in this class / this instructional unit?

11. What are your suggestions for further improvements in the practical teaching of EMR instructional units?

Appendix 4 – Questionnaire about the examination of EMRS practical skill

Questionnaire for the EMR system instructional unit #2

Name (will be anonymized, but is still needed for coding purposes):

1. How long did it take for you to complete each task (please fill in the time needed)?

   - ✓ Scenario 1 step 1 (total TTS: 20 minutes)
     - Sub-step 1:
       - __ minutes
       - Any (other) problems? _____
     - Sub-step 2:
       - __ minutes
       - Any (other) problems? _____
     - Sub-step 3:
       - __ minutes
       - Any (other) problems? _____
     - Sub-step 4:
       - __ minutes
       - Any (other) problems? _____

     - Did you finish the whole step 1 in the given TTS (yes/no)? ____

   - ✓ Scenario 1 step 2 (total TTS: 10 minutes)
     - Sub-step 1:
       - ___ minutes
       - Any (other) problems? _____

     - Did you finish the whole step 2 in the given TTS (yes/no)? _____

   - ✓ Scenario 1 step 3 (total TTS: 15 minutes)
     - Sub-step 1:
       - ___ minutes
       - Any (other) problems? _____

     - Sub-step 2:
       - ___ minutes

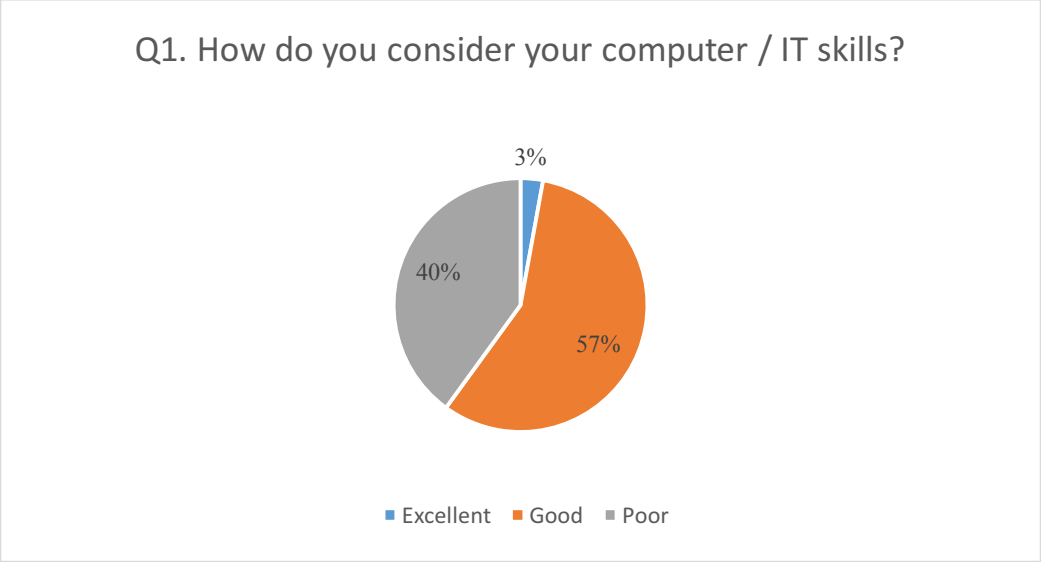
        - Any (other) problems?
          _____

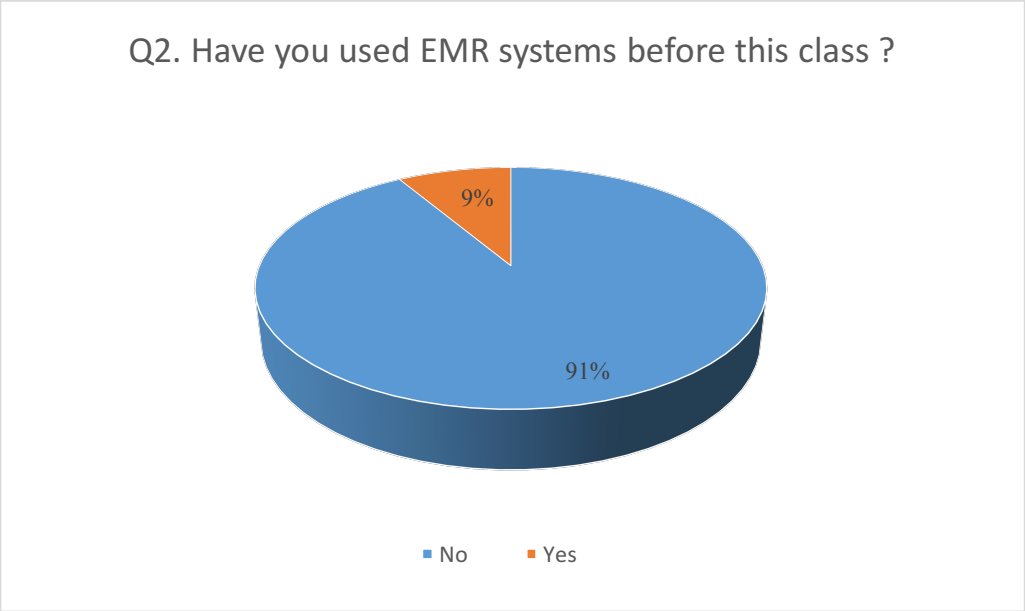
    - Did you finish the whole step 3 in the given TTS (yes/no)? _____

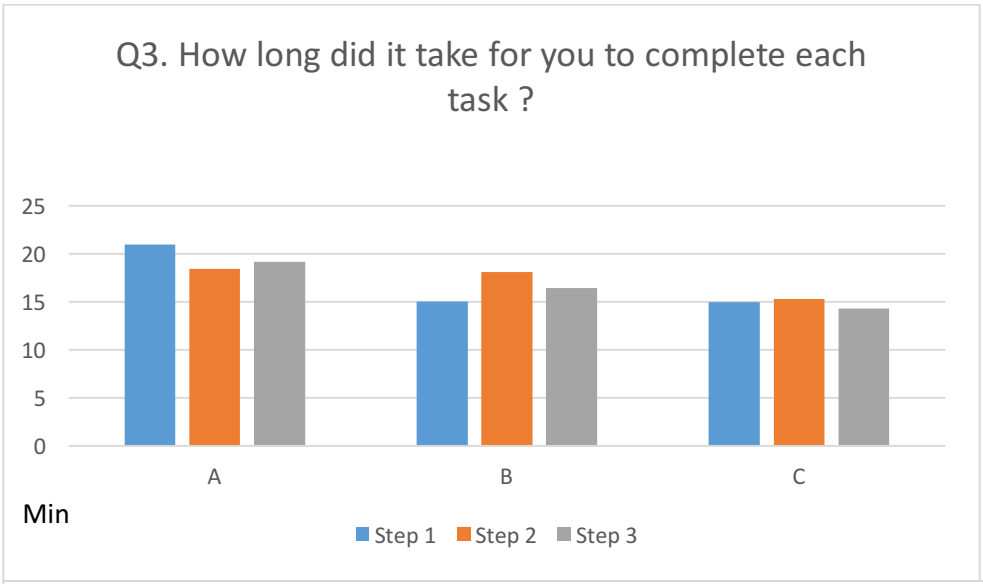
2. Did you enjoy this EMR system more than the last one? Why and how is it better or worse?

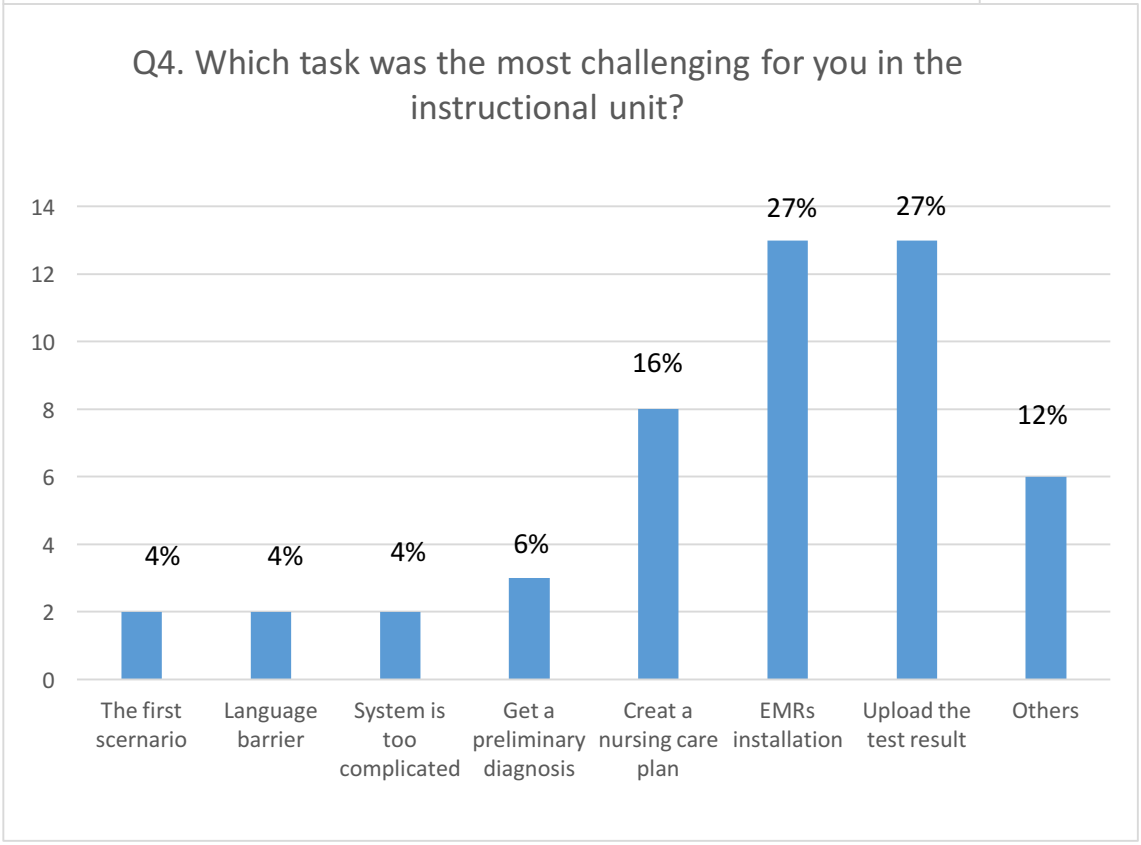
3. After solving the instructional units with the different EMR systems, what is your opinion on the features that a good EMR should have (except for other languages)?

Appendix 5 – Results of the questionnaire about instructional unit

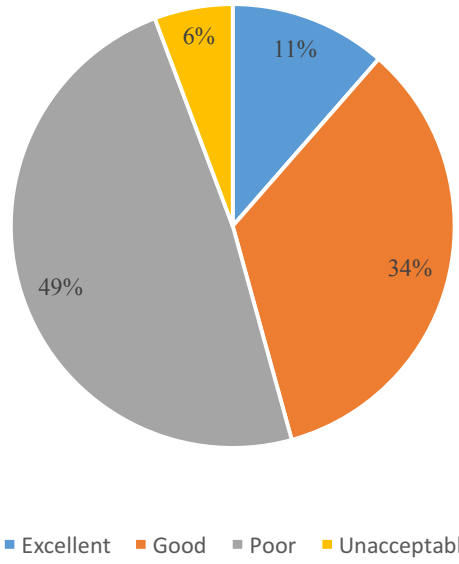




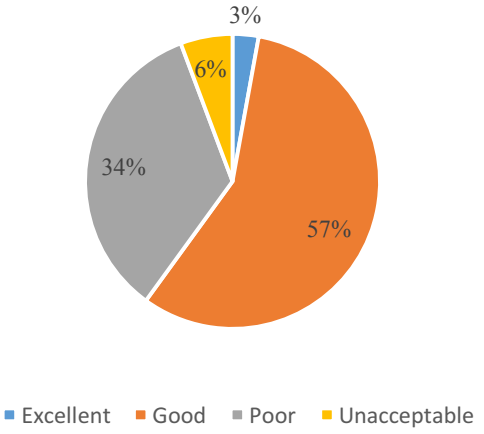

Q3. How long did it take for you to complete each task ?
25
20
15
10
5
0
A
B
C
Min
Step 1
Step 2
Step 3

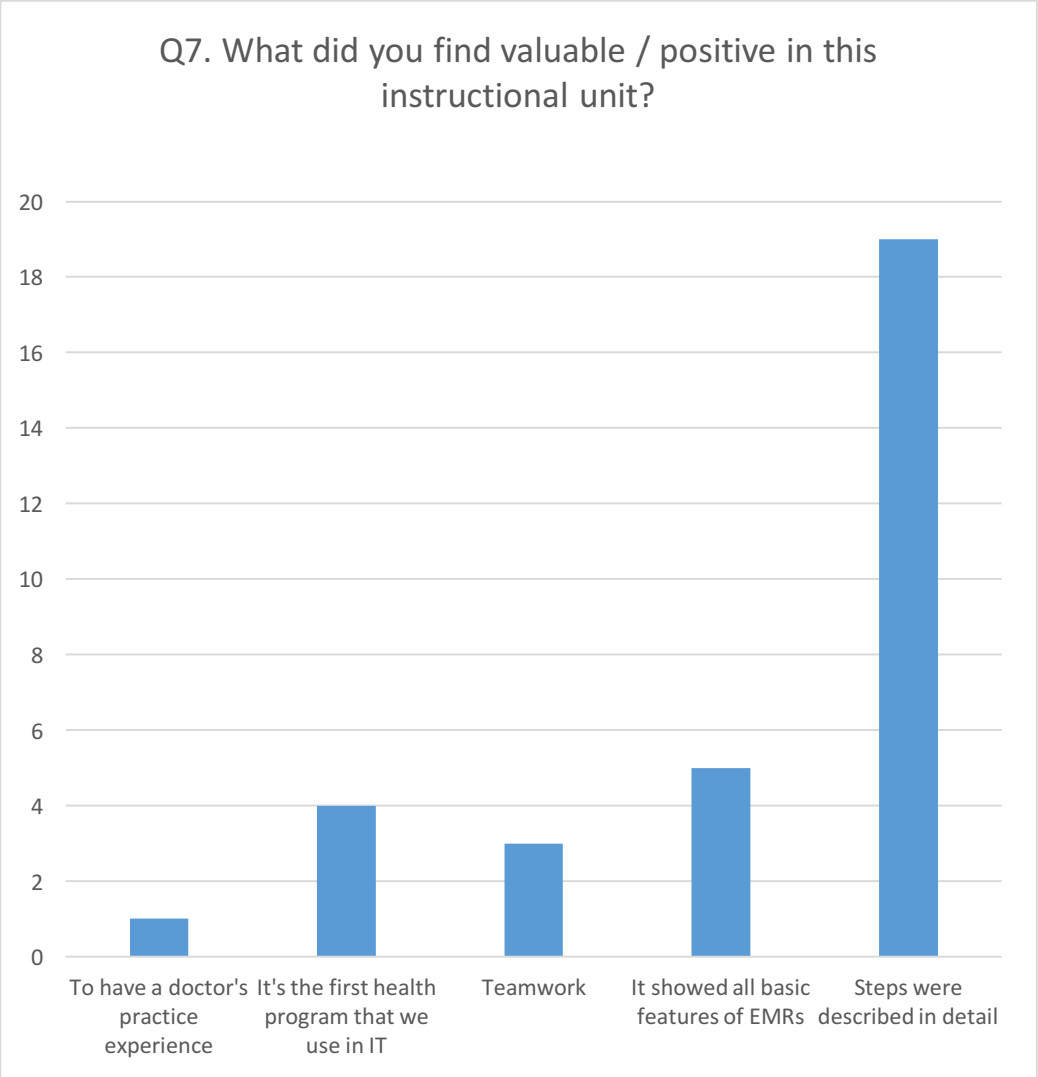

Q4. Which task was the most challenging for you in the instructional unit?
14
12
10
8
6
4
2
0
4%
4%
4%
6%
16%
27%
27%
12%
The first scernario
Language barrier
System is too complicated
Get a preliminary diagnosis
Creat a nursing care plan
EMRs installation
Upload the test result
Others

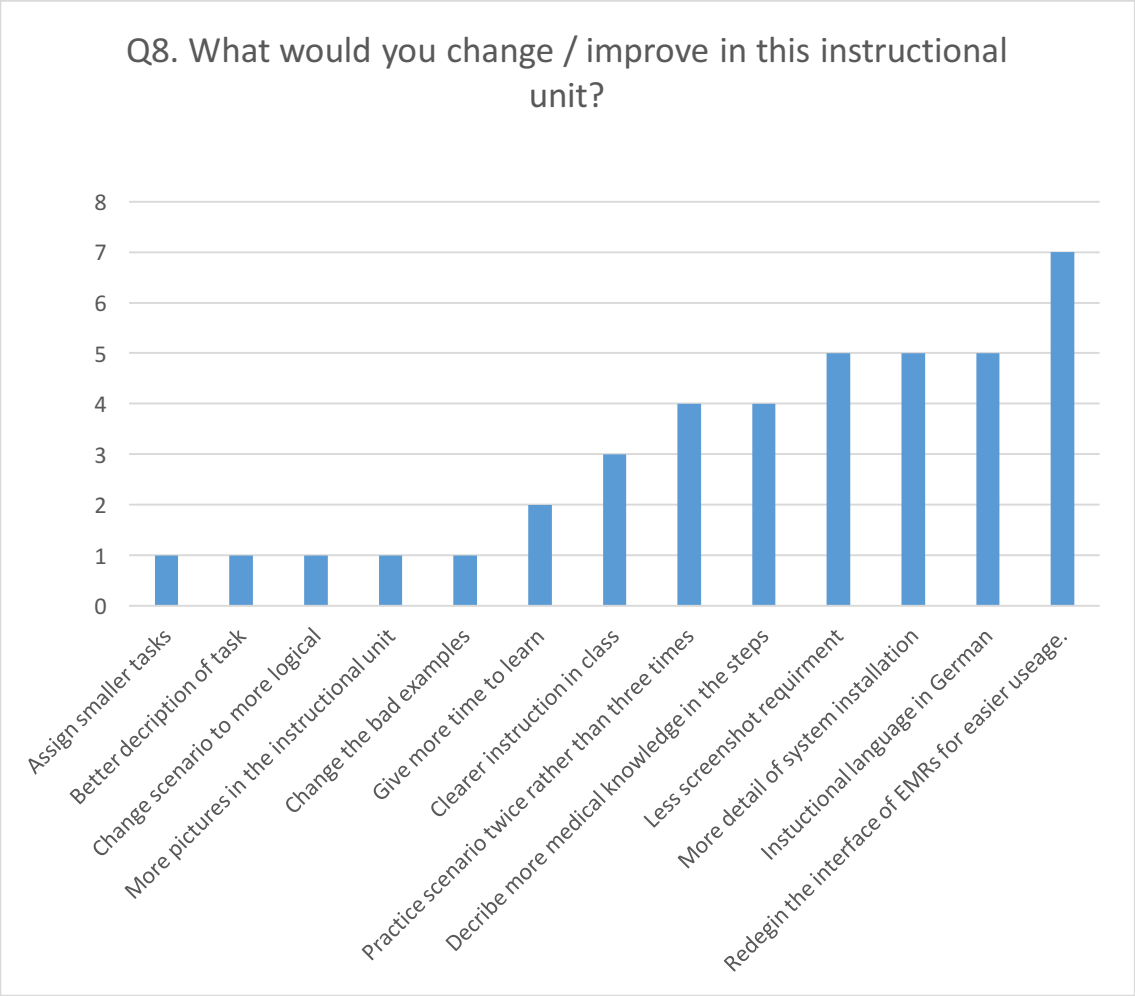
Q5. Was the provided background information sufficient to work on the instructional unit and were the task-related instructions clear at the beginning of the class ?

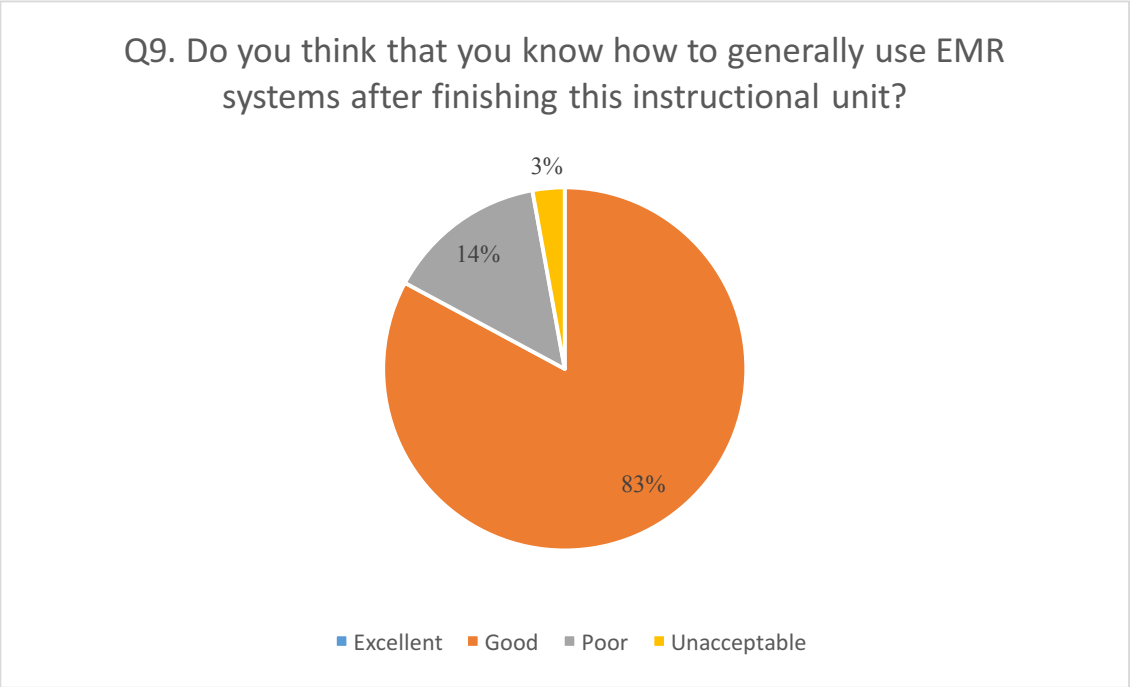


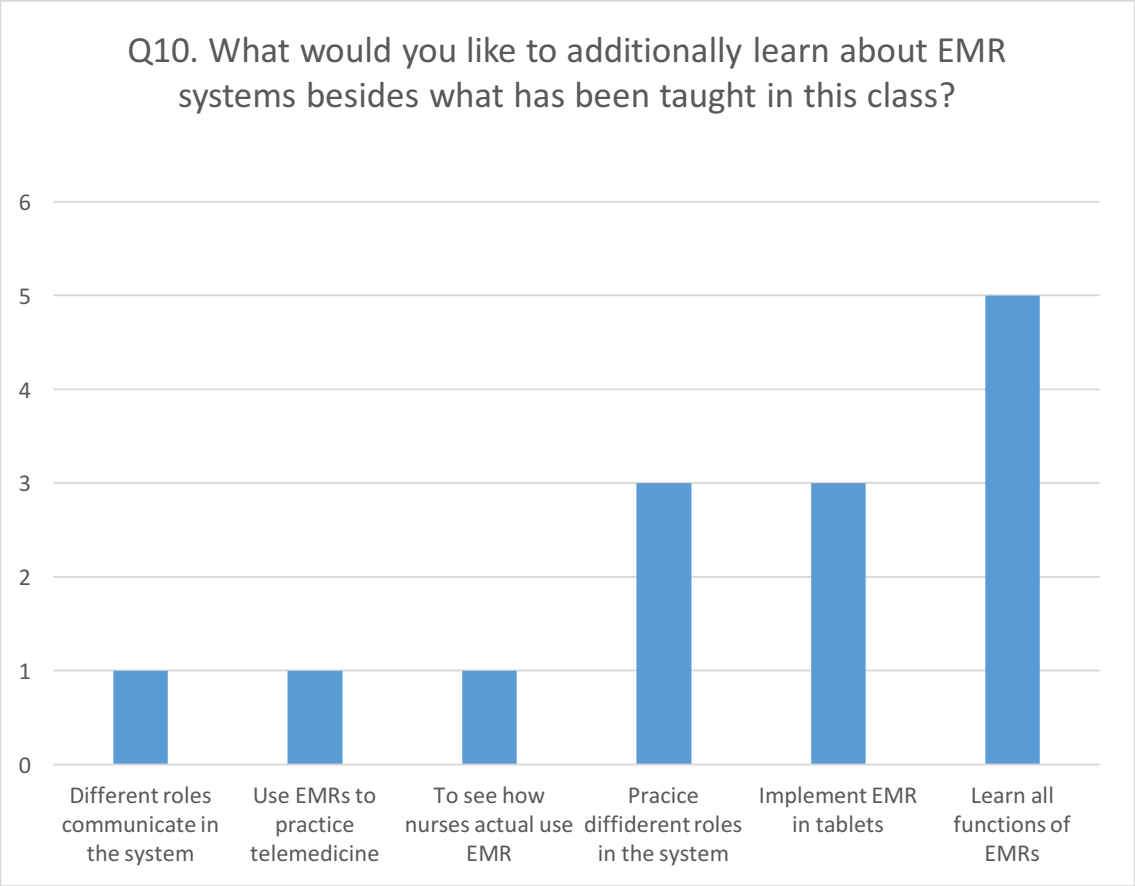
Q6. Do you think this instructional unit is generally well structured?

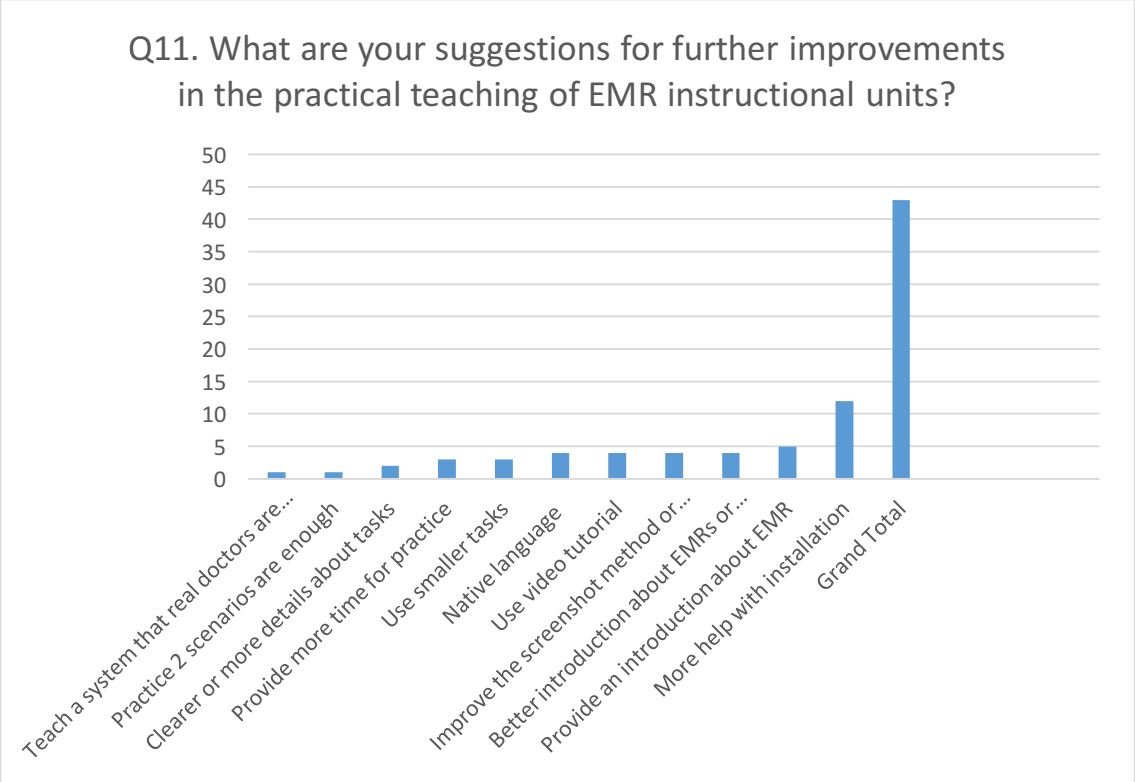



Q7. What did you find valuable / positive in this instructional unit?
20
18
16
14
12
10
8
6
4
2
0
To have a doctor's practice experience
It's the first health program that we use in IT
Teamwork
It showed all basic features of EMRs
Steps were described in detail


Q8. What would you change / improve in this instructional unit?
8
7
6
5
4
3
2
1
0
Assign smaller tasks
Better decription of task
Change scenario to more logical
More pictures in the instructional unit
Change the bad examples
Give more time to learn
Clearer instruction in class
Practice scenario twice rather than three times
Decribe more medical knowledge in the steps
Less screenshot requirment
More detail of system installation
Instuctional language in German
Redegin the interface of EMRs for easier useage.


Q9. Do you think that you know how to generally use EMR systems after finishing this instructional unit?
3%
14%
83%
Excellent
Good
Poor
Unacceptable


Q10. What would you like to additionally learn about EMR systems besides what has been taught in this class?
6
5
4
3
2
1
0
Different roles communicate in the system
Use EMRs to practice telemedicine
To see how nurses actual use EMR
Pracice diffidierent roles in the system
Implement EMR in tablets
Learn all functions of EMRs


Q11. What are your suggestions for further improvements in the practical teaching of EMR instructional units?
50
45
40
35
30
25
20
15
10
5
0
Teach a system that real doctors are...
Practice 2 scenarios are enough
Clearer or more details about tasks
Provide more time for practice
Use smaller tasks
Native language
Use video tutorial
Improve the screenshot method or...
Better introduction about EMRs or...
Provide an introduction about EMR
More help with installation
Grand Total

Appendix 6 – The Modifications of instructional unit

The original instructional unit (Appendix 1) was used for conducting the first study. The most parts of the original instructional unit will remain same, only a few changes were made in order to improve the learning outcomes.

The modifications were done after completed the evaluation of the first questionnaire (Appendix 5). The modification of the instructional unit used terms, original text, modified text, and reasons in order to have a clear layout of modified information regarding the original one. There are total 6 terms have been modified by taking feedback from the students into consideration.

Term 1: Learning goals

Original text:

- Students learn to use EMR systems

Register new patient in the system

Search for a patient in the system

Schedule an appointment for the patient

Write medical a note in the system

Write diagnosis in the system

Write diagnosis in the system

Order examination for the patient in the system

Upload test result in the system

Write nursing care plan in the system

- Students can use EMR system to practice patient care after this instructional unit

Modified text:

1) Students understand the concept of the EMRS.

2) Students can list different parts and functions of the EMRS.

3) Students improve interpersonal, communication and teamwork skills.

4) Students can perform following activities in the system independently: registering a new patient, searching for a patient, scheduling an appointment for the patient, writing medical a note and diagnosis, ordering an examination for the patient, uploading the test result, writing a nursing care plan.

5) Students can use the help menu or the wiki from the EMR provider to solve practical problems when they occur.

6) Students can evaluate each other's learning outcome according to the grading criteria

7) Students can use EMR systems from other companies or organizations.

8) Students can list the places that EMR systems are used.

9) Students can write down the necessary steps to achieve the EMRS processes.

10) Students can explain the necessary steps to achieve the EMR processes.

Reasons:

The author of this thesis used Revised Bloom's Taxonomy method to redefine learning goals in order to have clearer learning goals regarding the whole instructional unit and training purpose.

Term 2: Procedures

Original text:

- Last class, switch scenarios with different groups, also switch roles for group members, practice once more.

- Students grade each other with grading criteria, create a random name list of students, the first person in the list grade the second person, the second person grade the third person and so on, the last person grade the first person in the list.

Modified text:

- Last class, switch scenarios with different groups, also switch roles for group members, practice once more. (Note: Practice two scenarios will be sufficient enough.)

- Students grade each other with grading criteria, avoid mutual grade and possible biases such as friendship, gender.

Reasons:

From the first questionnaire result, some students mentioned that they would like to practice scenario twice rather than three times. From the Question three in the first questionnaire, the duration used to complete each task are similar to scenario B and scenario C. According to those reasons, the author of this thesis agrees that practice two scenarios is sufficient in this instructional unit.

Term 3: Case study

Original text:

The case study will use OpenEMR System as practice system. First of all, install OpenEMR system in the computer, the installation instructions can be found in this link http://www.open-emr.org/wiki/index.php/OpenEMR_Installation_Guides; After successfully installed system, the instructor should create new accounts for students to practice case study. There are total three scenarios, each scenario has three steps with several tasks listed.

Modified text:

The case study will use OpenEMR System as practice system. First of all, install OpenEMR system in the computer, the installation instructions can be found in this link http://www.open-emr.org/wiki/index.php/OpenEMR_Installation_Guides; After successfully installed system, the instructor should create new accounts for students to practice case study. There are total three scenarios, each scenario has three steps with

several tasks listed. Students are allowed to use online resources to help with medical knowledge and practical obstacles. This instructional unit are more focused on the EMRS practice skills rather than medical knowledge examination, therefore, the uncorrected answer relating to medical knowledge will not affect the grade. However, the EMRS processes and tasks should be done as required.

Reasons:

The author of this thesis added some details relating to study methods and evaluation criteria. The reason for such changes is mainly for emphasizing the eLearning method, encouraging the students to do self-learning more by using eLearning approach. From the result of the first questionnaire, some students mentioned that they had difficulties with the diagnosis which belongs to the medical knowledge. Therefore, they need to understand a wrong diagnosis will not affect their learning outcome regarding the learning goals in this instructional unit.

Term 4: Scenario

Original text:

Patient 1: A married male named Shepard Smith, born on 1st Jun 1957, ID code is 08570601, he lives at Frankensteiner Straße 20, 60594 Frankfurt, Germany. His body weight is 80 Kg and Height is 188cm.

Patient 2: A 46-year-old single woman, born on 1 Dec, 1970, ID code is 08701201. Her name is Jane, she came to her GP as she has been feeling unwell over the last few months and things appear to be getting worse, she lives in Amsinckstrasse 39, 20097 Hamburg, Germany. Her body weight is 68 Kg and height is 168 cm.

Patient 3: A 50-year-old gentleman called Karl, born on 29 Oct, 1967, ID code is 08671029, he presents to his GP with back pain, he comes from Goethestrasse 15, 80336 Munich and lives in Berlin. His body weight is 88 Kg and height is 186cm.

Modified text:

Patient 1: A married male named Shepard Smith, born on 1st Jun 1957, ID code is 08570601, he lives at Frankensteiner Straße 20, 60594 Frankfurt, Hesse, Germany. His body weight is 80 Kg and Height is 188cm.

Patient 2: A 46-year-old single woman, born on 1 Dec, 1970, ID code is 08701201. Her name is Jane, she came to her GP as she has been feeling unwell over the last few months and things appear to be getting worse, she lives in Amsinckstrasse 39, 20097 Hamburg, Hamburg, Germany. Her body weight is 68 Kg and height is 168 cm.

Patient 3: A 50-year-old gentleman called Karl, born on 29 Oct, 1967, ID code is 08671029, he presents to his GP with back pain, he comes from Goethestrasse 15, 80336 Munich, Bavaria, Germany. His body weight is 88 Kg and height is 186cm.

Reasons:

The author added "state" information in each patient's personal information, although the OpenEMR doesn't require the user to fill this information mandatory. However, one student mentioned that he or she has to search for this information in order to fill it in the system. This issue may occur to some students when they practice, then add this information may help that student saving time in practice.

Term 5: Task

Original text:

2) Please keep a screenshot of each step from the computer, and document them in a word file in the same order as the steps.

Modified text:

2) Please take a screenshot/photo of each step from the computer, and document them in a word file in the same order as the steps.

Reasons:

In the modified instructional unit, the students can choose to take a photo of the computer screen for each step since the majority of students have a smartphone with a camera function, this may help students solve screenshots issue.

The author deleted the living address of the patient 3, some students got confused with living and birth address, and they were not sure which address they should use for filling address information in the system. In this case, one address can give students a clear mind with registering the patient 3 in the system.

Term 6: Step 2

Original text:

10 minutes

Modified text:

15 minutes

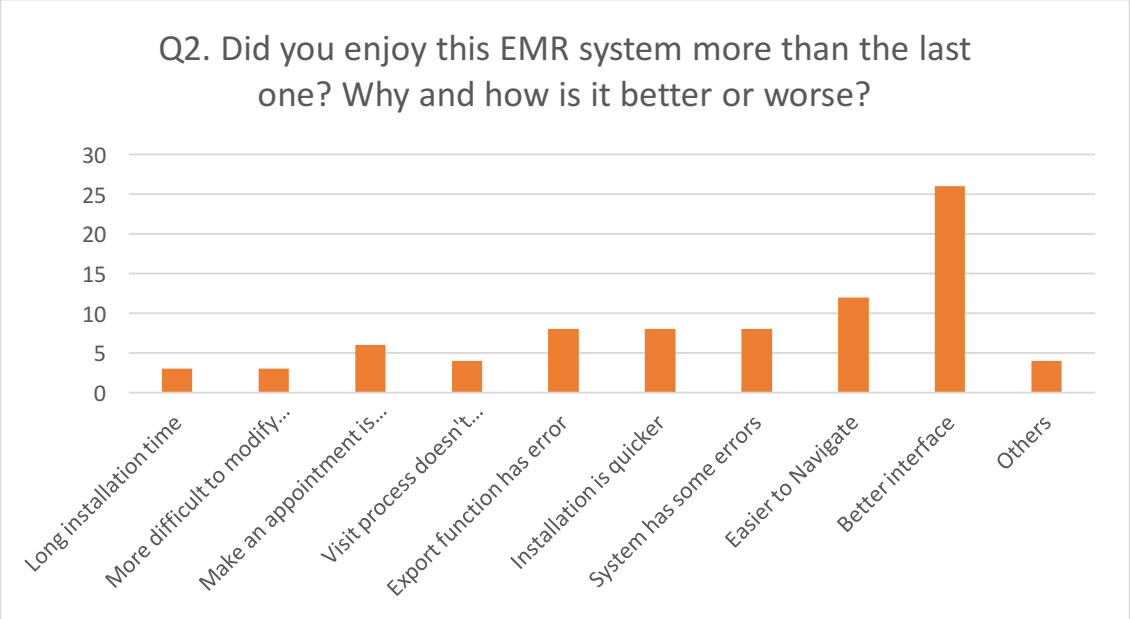
Reasons:

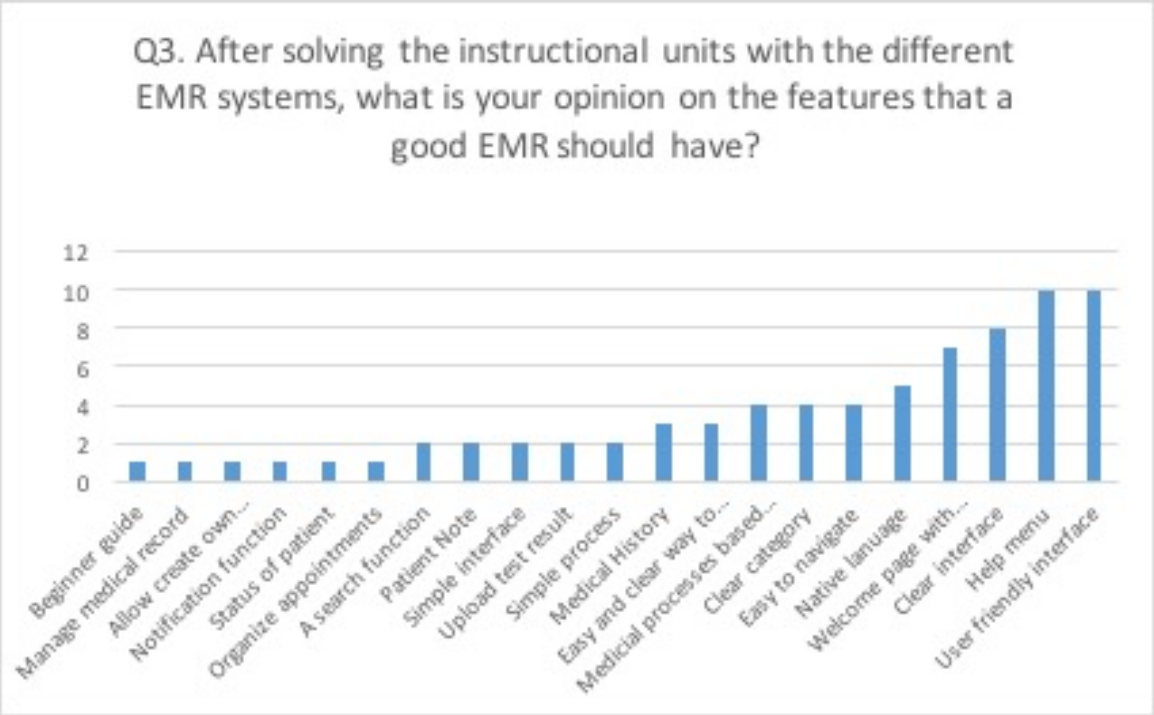
As the results from the first questionnaire, the question 3 showed that average duration for completing step 2 was 17 minutes, it is possible to increase the practice time for step 2 by considering the length of the class. Therefore, the teacher will give students 15 minutes to practice step 2.

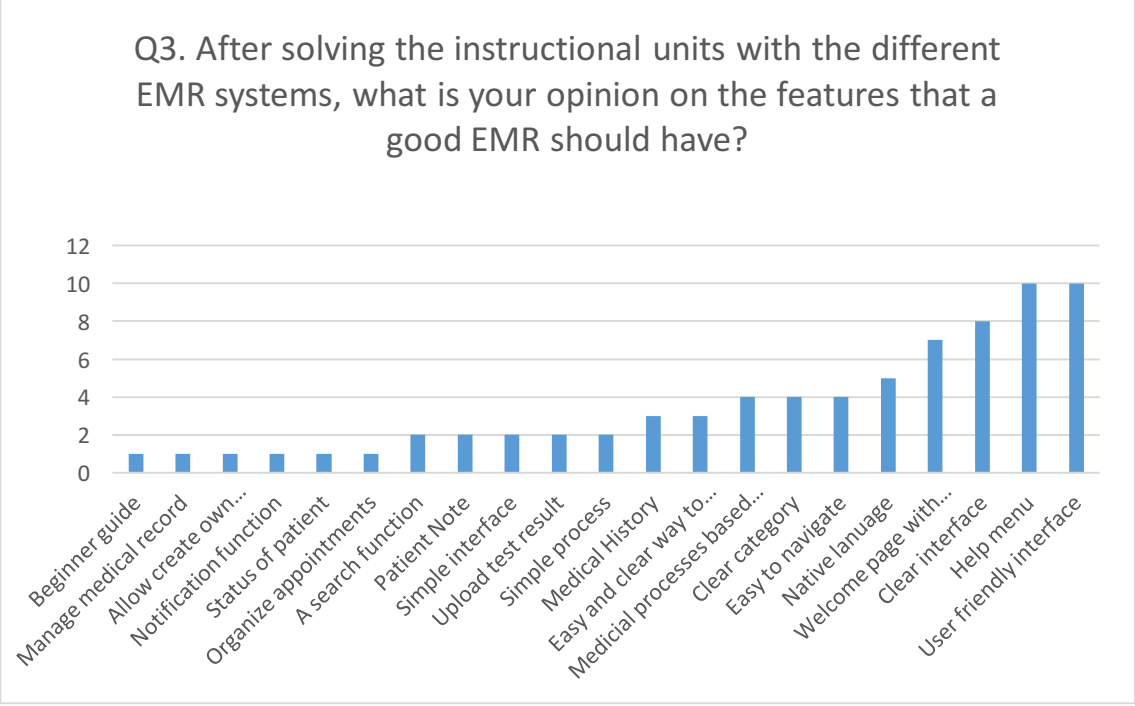
Appendix 7 – Results of the examination of EMRS practical skill and the second questionnaire

Q1. How long did it take for you to complete each task? Did you finish whole step?

Step	Average Duration	Number of failed	Average Duration	Number of succeeding
Step 1	67	2 (6%)	20	34 (94%)
Step 2	12	23 (64%)	6	13 (36%)
Step 3	16	10 (28%)	14	26 (72%)




Q3. After solving the instructional units with the different EMR systems, what is your opinion on the features that a good EMR should have?
12
10
8
6
4
2
0
Beginner guide
Manage medical record
Allow create own...
Notification function
Status of patient
Organize appointments
A search function
Patient Note
Simple interface
Upload test result
Simple process
Medical History
Easy and clear way to...
Medical processes based...
Clear category
Easy to navigate
Native lanuage
Welcome page with...
Clear interface
Help menu
User friendly interface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Patient Note
Simple interface
Upload test result
Simple process
Medical History
Easy and clear way to...
Medical processes based...
Clear category
Easy to navigate
Native lanuage
Welcome page with...
Clear interface
Help menu
User friendly interface