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# Design, development, and evaluation of an interactive training simulator for teaching hospital information systems

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## Abstract:

**BACKGROUND:** In their apprenticeship program, health information technology (HIT) students are deprived of the ample opportunity to work with the hospital information system (HIS). This study aimed to design an interactive simulator for the HIS training and evaluate its effects on the informatics skills of HIT students.

**MATERIALS AND METHODS:** This study was conducted on 16 Bachelor of Science students of HIT at Kashan University of Medical Sciences in 2019. After the functionalities and features of the simulator were determined based on similar existing simulators, expert opinions were received to simulate eight important processes of admission, discharge, and transfer module in HIS. The scores of students' skills and time taken to perform the processes were recorded and analyzed before and after the educational intervention. After they were trained by the simulator, the students filled out a usability evaluation questionnaire. The data were then analyzed in SPSS version 21.

**RESULTS:** The simulators of health information systems were characterized by interactivity, multimedia applications, practice exercises, tests, and feedback. After the students were trained by the developed simulator, their skills scores improved significantly in 75% (6/8) of the processes, and the timespans of all processes decreased significantly ( $P < 0.05$ ). The usability evaluation indicated the usability of the simulator was at a "good" level.

**CONCLUSIONS:** According to the study results, using the simulator improves the informatics skills of HIT students in working with HIS. It is recommended that this method also be used in other apprenticeship programs to teach health information systems.

## Keywords:

Computer user training, health information systems, hospital information systems, simulation training

## Introduction

In the past two decades, information technology (IT) has developed significantly in the health sector. This technology includes a wide variety of information systems and tools helping collect, record, share, and manage health data electronically.<sup>[1]</sup> In Iran, hospital information systems (HISs) have received more attention than other IT achievements in the health sector. Since the implementation of the Health System Reform Plan in 2013, all the Iranian hospitals have been required to implement and

employ HISs. With the implementation of HISs, it is necessary for the healthcare service providers to acquire sufficient skills and competencies to work with these systems. For this purpose, it will be essential to train the students, who will become the end-users of such systems after graduation, to correctly work with these systems at universities of medical sciences. Studies have shown that proper and correct training results in the high acceptance of health information systems by users as well as the successful implementation of such system.<sup>[2,3]</sup>

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In their apprenticeship program, health information technology (HIT) students do not have the ample opportunity to work with the HIS due to certain constraints and considerations such as crowded environments of hospitals, the importance of maintaining information security, and the necessity of paying attention to patient safety; as a result, they might not acquire sufficient practical skills to work these systems.<sup>[4,5]</sup> Due to a few constraints on the training of practical skills in conventional education approaches, novel methods of virtual education are used today to improve the practical skills of students. Simulation is a virtual education method,<sup>[6]</sup> in which students can be trained with data of patients in a virtual environment, practice trial and error, repeat a training process many times, and gain the experience of working in a real environment without disrupting hospital procedures and jeopardizing information security and patient safety.<sup>[7,8]</sup> Two of the world-famous health information system simulation programs are SimEMR<sup>®</sup><sup>[9]</sup> and the OHSCU Simulation,<sup>[10]</sup> both of which simulated the electronic health record (EHRs) of patients in the US. The professors using these simulators for training stated that these systems were effective and useful in improving education quality.<sup>[9]</sup>

Many studies have evaluated the effects of simulation on the improvement of outcomes in relation to learning health information systems. Smith and Scholtz<sup>[11]</sup> indicated that using a simulator could improve preparedness and acceptance of students to use EHR. According to Haugen *et al.*,<sup>[12]</sup> the adoption rate of electronic medical records (EMR) was 70% higher for the providers who used simulation than for those who used conventional education approaches. In another study, Vishnu Mohan *et al.*<sup>[13]</sup> emphasized the importance of simulation for EHR training. Their results indicated that EHR simulation improved learning and performance among the end-users of this system and also increased health-care quality and patient safety. George *et al.*<sup>[14]</sup> showed that education through simulation could increase user speed and accuracy in using information systems.

According to the literature review, none of the studies in Iran has used virtual education methods, for example,

simulation, to train health information systems to health-care students. Given the importance of HISs and their extensive applications in hospitals, this study aimed to analyze, design, and develop an interactive simulator system to train HIT students in the use of HIS and evaluate the effects of such a virtual education method on the improvement of informatics skills among students. Furthermore, the usability of this simulator was assessed from the perspective of students.

## Materials and Methods

This was a developmental evaluation study which conducted in six steps at the Health Information Technology Laboratory of Kashan University of Medical Sciences and Health Services (KAUMS) in 2019 [Figure 1].

### Step 1: Reviewing papers and websites to determine functionalities and features of hospital information system simulator

The English papers and websites reporting the simulation of health information systems to train healthcare providers or students were reviewed by the research team in a systematic review study. The papers were searched in Medline (via PubMed), Cochrane, Scopus, and Web of Science databases, whereas the websites were searched in Google. Ten studies and eight websites that employed simulation training to teach health information systems were reviewed.

### Step 2: Receiving the opinions of medical informatics and health information management professors and health information management PhD candidates on functionalities of the simulator

Based on the data extracted from papers and websites, a questionnaire was designed to determine the functionalities of the simulator. Consisting of ten items, the questionnaire was designed in four sections, namely content functionalities of the simulator, interactive functionalities of the simulator, testing functionalities of the simulator, and simulator accessibility functionalities. After the reliability was confirmed ( $\alpha = 0.89$ ), the questionnaire was given to five professors holding PhDs in medical informatics

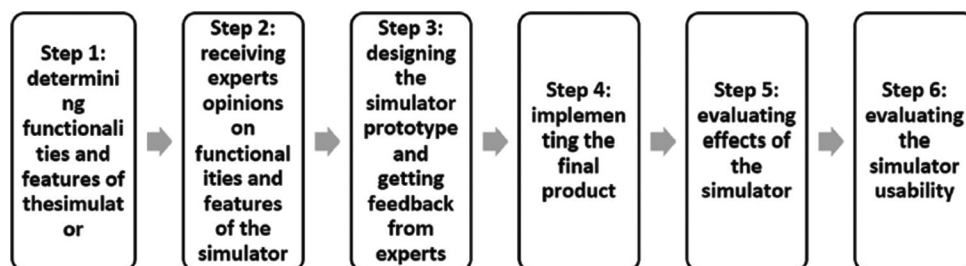


Figure 1: Steps of the research

and health information management as well as eight Ph.D. candidates of health information management. The responses of experts to the questionnaire items were scored on a five-point Likert scale (1-very low; 2-low; 3-medium; 4-high; 5-very high). The descriptive statistics (frequency and mean) were used to analyze the findings in the Statistical Package for the Social Sciences (SPSS) version 21.0 [IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.]. The minimum score for the acceptance of each item was considered 3.75.

### Step 3: Designing the simulator prototype and getting feedback from experts

Due to the extensive use of Shafa HIS (developed by Tirajeh Rayane Tehran Co, <http://www.trtco.com/>)<sup>[15]</sup> in Iranian hospitals (212 hospitals by May 21, 2020), this system was used for simulation in this study. It was important and useful to train the HIT students in working with the admission, discharge, and transfer (ADT) module than other modules. Therefore, this module was selected for simulation based on the professors' opinions. With the approval of the health information management department manager in the hospital, eight processes were selected from the ADT module for simulation. These processes were inpatient admission, outpatient admission, Admission with previous referral code, diagnostic codes recording, edit patient information, report disease diagnostic codes, report the hospital departments performance, and report the services provided to the patient. In another study, researchers evaluated the usability of this HIS in performing these eight processes.<sup>[16]</sup>

Based on the functionalities and features selected in the previous steps, the general schema of the simulator was designed and developed by using Adobe Captivate 2019 v. 11, Adobe Photoshop CC 2019, Adobe Illustrator CC 2019 v. 23, Adobe Audition CC 2019 v. 12, Camtasia Studio 2019.0.10, and Microsoft Visual Studio 2013 Ultimate.

In this simulator, each process consists of three sections, i.e., teaching, practicing, and testing.

- Teaching section: Each process is performed by the simulator through the real data of patients. The implementation of a process is explained to learners (HIT students) in an audio-visual format
- Practicing section: The simulator introduces a patient to the learner, and the learner should perform the process steps for the hypothetical patient. In this section, the simulator guides the learner, and the user can perform the process many times without any restrictions
- Testing section: The simulator introduces a patient to the learner, and the learner should complete the

process for that patient. In this section, the learner is provided the process time and the score. In the testing section, the learner can repeat an error for three times, and the simulator will then perform that step of the process and automatically subtracts the score.

After the simulator was designed, the prototype was given to three Ph.D. candidates of health information management and three experts of the Health Information Management Department of Shahid Beheshti Hospital at Kashan to get feedback. After working with the system prototype, the students and experts wrote their opinions and criticisms to the researchers.

### Step 4: Implementing the final product (hospital information system simulator)

With the opinions of professors and experts on the prototype, the problems and flaws were eliminated to implement the web-based simulator in the Health Information Technology Laboratory of KAUMS at the beginning of the first semester in the academic years 2019–2020. Training one part of the HIT apprenticeship (10 hours) in the BSc program was performed by this simulator, which was approved by the faculty members of the Department of Information Technology and Management at KAUMS.

### Step 5: Evaluating effects of the simulator on the improvement of informatics skills among BSc students

In this step, the simulator was given as the apprenticeship program to 16 BSc students of HIT. The students were first trained in how to use the simulator for 45 minutes. They were then given a test on how to perform the eight processes of the simulator based on what they had learned previously. Their scores were then recorded on an evaluation form consisting of the process name, timespan, and score. The simulator was available to the students for four weeks so that they could learn how to execute the processes. After four weeks of training, they were retested in the eight processes, and their timespans and scores were recorded on the evaluation form. The score of each process was based on its steps, and every mistake subtracted one score from the student who made it. At both rounds, the tests were performed through the simulator in the presence of a researcher. After the data were collected, they were analyzed to determine the mean score and timespan of each process and the pretraining and posttraining mean difference through the Wilcoxon test in the Statistical Package for the Social Sciences (SPSS) version 21.0 [IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.].

### Step 6: Evaluating the simulator usability from the perspective of students

After the students worked with the simulator for four

weeks, they were given the QUIS questionnaire<sup>[17]</sup> to evaluate the usability of this education instrument. The scores were then averaged at “good” (6–9), “medium” (3–6), and “poor” (0–3) levels.

## Results

### Step 1: Reviewing papers and websites to determine functionalities of the simulator

Searching for papers and websites resulted in the review and analysis of ten papers and websites which had simulated health information systems. The most important functionalities and features of the simulators used in those papers and websites included interactivity, multimedia applications, practice exercises, testing, giving feedback, and presenting various scenarios.

### Step 2: Receiving feedback from medical informatics and health information management professors and Ph.D. candidates of health information management on functionalities and features of the simulators

The questionnaire included ten items, which were provided for professors based on the analysis of functionalities and features reviewed in papers and websites. According to the analysis of findings, all ten items of the questionnaire were necessary for experts (mean >3.75) [Table 1].

### Step 3: Designing a prototype of the simulator and receiving feedback from students and experts of health information management departments of hospital

The simulator was developed in training, practicing, and testing with its user interface designed and developed in Visual Studio 2013. The health information management experts wrote their opinions to the researchers, and the necessary modifications were made accordingly. Figures 2-5 show different user interfaces of the simulator.

### Step 4: Installing and implementing the final product

The flaws were pinpointed by experts and Ph.D. candidates of health information management in the previous step. After the flaws were eliminated, the final simulator was installed and implemented at the Health Information Technology Laboratory of KAUMS (on 25 computer work stations).

### Step 5: Evaluating effects of the simulator on informatics skills of students in the health information technology apprenticeship program

Table 2 indicates the mean scores of students’ skills before and after the training through the simulator. According to the results, the mean scores of students’ skills in six processes (75%) increased significantly after they were trained by the simulator.

#### *Analysis of mean timespan of processes*

According to the analysis of timespans of processes performed by students [Table 3], the mean timespan of all processes decreased significantly after the training was performed through the simulator ( $P < 0.05$ ).

### Step 6: Simulator usability evaluation results from the students’ perspective

Table 4 shows the results of the usability evaluation of the simulator. In all areas, students evaluated the simulator usability at a good level (based on poor, medium, and good levels). The highest score was given to the terminologies and information of the simulator ( $8.31 \pm 0.85$ ), whereas the lowest score was given to the general operability of the simulator ( $7.44 \pm 1.16$ ).

## Discussion

Simulation training provides students with the opportunity to practice repetitively before actual engagement in the real clinical environment. Using

**Table 1: Score of simulator functionalities**

Functionalities of the simulator	Average	Accept/reject
Content of the simulator		
Simulator provides various educational scenarios	4.61	Accept
Teaching the scenarios to the student should be purposeful	4.53	Accept
Interactive functionalities of the simulator		
User interface of the simulator is the same as the actual HIS in the hospital	4.38	Accept
Provide feedback to the user	4.53	Accept
Use multimedia	4.46	Accept
The user has the ability to control (stop, play and movement) training	4.61	Accept
Simulator accessibility		
Ability to access the simulator outside the laboratory environment	4	Accept
Access the simulator offline (on CD or flash memory)	3.84	Accept
Simulator has a user guide	4.53	Accept
Test and exam	4.61	Accept

HIS=Hospital information system

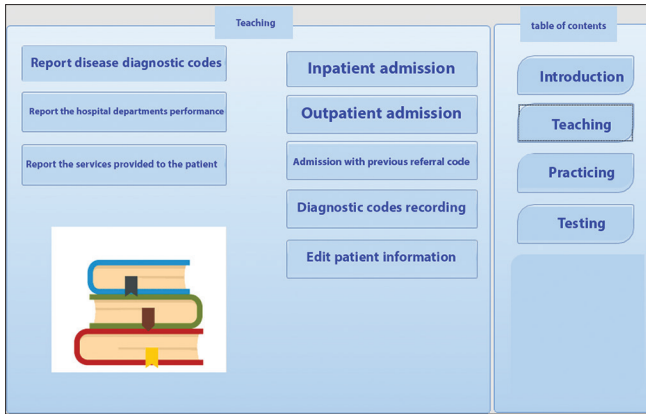


Figure 2: Processes

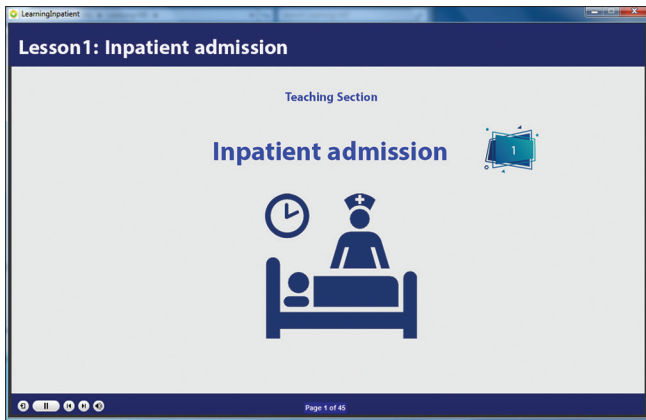


Figure 4: Teaching section

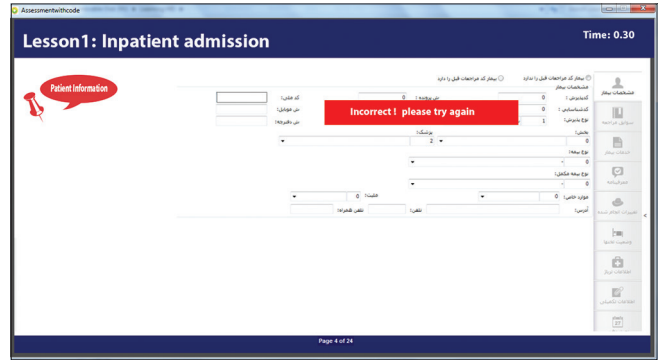


Figure 3: Practicing section

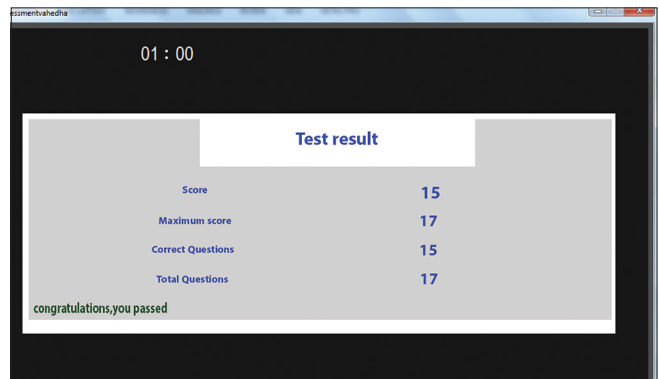


Figure 5: Testing section

simulation training, students are trained without compromising patient safety and confidentiality of information. This study is aimed to determine functionalities and features, design, and implement an interactive simulator system for the HIS training and evaluate its effects on the informatics skills of HIT students. The functionalities of health information systems were identified as interactivity, multimedia applications, practice exercises, testing, and feedback. According to the results, the HIS training through simulation helped students perform the system processes faster and generally improved their informatics skills.

According to Mohan *et al.*,<sup>[13]</sup> EHR training simulation should have the abilities to perform practice exercises and give feedback anytime. The practice exercise capability helps students repeat a process many times so that any error possibility can decrease in working with the real system. Moreover, the ability to give feedback anytime helps students see their performance results and modify them if any error occurs. These functionalities are consistent with the practice exercise and feedback capabilities of the simulator proposed in this study. This simulator is also characterized by the ability to take tests and display test results. This functionality is

consistent with the research finding of Kushniruk *et al.*,<sup>[18]</sup> who showed that taking tests and displaying the results were among the essential factors in developing an EHR training simulator.

According to the data analysis, the scores of students' skills increased in most of the processes after using the simulator. The outcome of skill is important because incompetence in working with information systems can result in the refusal of this system on the part of health-care providers. In fact, the refusal can lead to the unsuccessful implementation and failure of these systems.<sup>[19]</sup> Boryck and Kushniruk *et al.*<sup>[20]</sup> showed that insufficient knowledge of health information systems might cause the incidence of errors. According to the Quality and Safety Education for Nurses center, five necessary competencies of nurses depend on their sixth competency, i.e., informatics skills.<sup>[21]</sup> Researchers indicated that HIS training through simulation could act as an appropriate method for improving the skills of health-care providers.<sup>[22]</sup> Moreover, Shachak *et al.*<sup>[23]</sup> showed that the simulator had positive effects on the skills and competencies of students in working with the EMR. In a study by Borycki *et al.*<sup>[24]</sup> the simulator improved the informatics skills of students in working with EHR. The results of these studies are consistent with the findings of the present study.

**Table 2: Mean scores of students' skills before and after training with the simulator**

Process	Total score	Pretest score	Posttest score	P
Inpatient admission	32	29.13±6.47	31.25±2.26	0.001
Outpatient admission	33	32±1.21	32.63±0.80	0.101
Admission with previous referral code	19	18.69±3.42	18.88±0.34	0.007
Diagnostic codes recording	5	4.34±0.51	4.69±0.47	0.046
Edit patient information	15	13.75±0.85	14.38±0.95	0.02
Report disease diagnostic codes	18	16.19±0.91	16.38±0.88	0.02
Report the hospital departments performance	17	15.69±1.35	16.94±0.25	0.01
Report the services provided to the patient	9	8.94±0.25	9	0.31

**Table 3: Timespan of processes before and after training with the simulator**

Process	Pretest time	Posttest time	P
Inpatient admission	6.81±1.61	3.57±1.18	0.003
Outpatient admission	6.06±1.76	2.62±0.96	<0.001
Admission with previous referral code	4.75±0.44	1.86±0.60	<0.001
Diagnostic codes recording	4.44±0.81	1.41±0.73	<0.001
Edit patient information	4.55±1.61	1.52±0.81	<0.001
Report disease diagnostic codes	4.75±0.85	1.72±0.64	<0.001
Report the hospital departments performance	4.51±1.22	1.15±0.50	<0.001
Report the services provided to the patient	4.92±1.03	1.15±0.71	<0.001

**Table 4: Results of usability evaluation of the simulator**

Usability evaluation area	Mean±SD
Overall reaction to the software	7.44±1.16
Screen design and layout	7.51±1.3
Terminology and systems information	8.31±0.85
Learning	8.23±0.99
System capabilities	7.70±1.22

SD=Standard deviation

According to the analysis of process timespans in this study, the timespans of all processes, performed by students, decreased significantly after the training was done through the simulator. This shows that training through the simulator increased the speed at which the tasks were performed. There are numerous factors in user satisfaction with health information systems; the most important one is time.<sup>[25]</sup> A challenge to the successful implementation of information systems is the time-consuming execution of processes in such systems.<sup>[26]</sup> The time-consuming execution of processes in health information systems is a refusal factor on the part of users.<sup>[27]</sup> George *et al.*<sup>[14]</sup> indicated that the nurses spent significantly less time working with the EHR after they were trained by simulator.

The users evaluated the simulator usability at good levels in all areas. Usability evaluation is important because the low usability of software can decrease

its popularity and acceptance.<sup>[28]</sup> In a study by Elliott *et al.*,<sup>[29]</sup> students indicated the simulator usability at a good level, a finding which is consisting of the results of this study.

According to the literature review, the simulation method has not been used for HIS training in Iran yet. However, there were a few limitations in this study. The simulator was designed for ADT module of a HIS; thus, this product cannot be used for the training of other modules and other HISs. Moreover, the system was evaluated by 16 students of one department in one university; hence, the study should be conducted on a larger scope to generalize the results.

Since it has been proven that using a simulator increased the informatics skills of students in working with the HIS, it is recommended that universities, health-care providers, and HIS developers benefit from these systems to train students and personnel. It is also recommended that future studies compare the cost-effectiveness and other effects of the simulation method with those of other education methods for the HIS training.

## Conclusions

In this study, a simulator was developed for HIS training. The simulator was implemented at the HIT laboratory of KAUMS. It was then made available to the BSc students of HIT. According to the evaluation results, using the simulator for the HIS training improved students' skills in working with the HIS. It is recommended that this novel, virtual, education method is used in other apprenticeship programs to teach health information systems and compare effects of this method with those of other education methods.

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## Conflicts of interest

There are no conflicts of interest.

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