Original Article

Development of a Web-Based Virtual Simulated Learning Environment for Pharmacy Practice Education

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ABSTRACT

Objective: In the present study, we aimed to develop a virtual simulation that allows pharmacy students to play through actual prescriptions and pharmacy practice scenarios productively and on a personal computer. If designed properly, this program may serve as a supplementary educational tool without the need for an existing human tutor that could provide learning outcomes as good as those resulting from traditional paper-based pharmacy practice tutorials. **Methods:** A computer-based simulation of a community pharmacy was developed. This program mainly targeted three basic learning needs of pharmacy students: drug dispensing, patient counseling, and dealing with clinical situations related to the patients' prescription or demand for over-the-counter (OTC) recommendations. Fundamental design decisions were based on breaking down the dispensing process into logical components to provide discrete development elements. For teaching patient counseling and clinical skills, instructors wrote scenarios covering the most prevalent pharmacy practice issues, mainly focused on medication use during pregnancy or lactation, OTC recommendations, information related to drug interactions and adverse drug reactions, and interactions between prescription drugs and patient's underlying disease. **Findings:** Based on the primary curriculum topics, the development team designed exercises for pharmacy practice units presented to year 5 pharmacy students. Accordingly, exercises were developed to authentically reflect tasks and challenges a community pharmacist would regularly face in the workplace. To fulfill this part, over 2000 real prescriptions were scanned and categorized based on the main drugs included. These prescriptions were used for both activities, namely medication dispensing and clinical scenarios. Furthermore, five senior pharmacy students wrote more than 200 clinical scenarios under a clinical pharmacist's supervision. The main objectives of pharmacy practice courses were followed to cover the most important must-to-know clinical tips, whether related to giving relevant advice as an OTC recommendation, referring the patient to a primary care physician, or just providing a piece of general health advice, which is expected to be comprehensively learned by pharmacy students. **Conclusion:** This program was designed as a simulated learning environment to help students develop prescription dispensing and clinical skills. To be considered a success, this simulation needed to provide equivalent or better learning outcomes than the current practice approach, which should be assessed in the future evaluation of the software, and then be promoted accordingly.

KEYWORDS: *Blended learning, pharmacy practice, simulation, virtual education, web-based software*

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INTRODUCTION

Shortage of qualified teachers and lack of funding for expanding educational opportunities are why some students do not learn as much as they should.[1,2] Due to the limitations of conventional education and the growth of information technology, alternative learning methods, like electronic (e)-learning, have been brought up. Virtual learning is a type of e-learning system which models traditional learning by providing virtual access to classes, tests, homework, feedback, etc.[3-5]

In healthcare education, students must learn and master clinical skills. Computer-based learning does appear to have a role in teaching clinical decision-making to students taking healthcare-related courses. Sibbald and Schlicht developed virtual patient case studies.[6-8] Orr enlisted the help of pharmacy faculty and residents with prior community pharmacy experience to act as virtual patients.[9] Kinkade developed a text-based computer program in which students made decisions on patients.[10]

Virtual education is not a substitute for traditional/ conventional learning methods, but it can improve effective learning in combination with the current style of education. Simulators present a high-quality real-like environment that is safe and satisfying for learners. The students will receive virtual education before real interaction with actual patients. Because the simulators reduce costs and increase the pace of learning, many educational planners are highly interested in them. Furthermore, blending different teaching styles improves students' participation in the course and high satisfaction rates.[11,12]

The results of various studies show that virtual education is an effective way to improve the knowledge and skills of pharmacy students. The pharmacy curriculum in Iran is for a 6-year Pharm. D degree. Students are typically given opportunities to practice clinical, dispensing, and counseling skills in educational pharmacies. At most Iranian universities, pharmacy students are sent on workplace-integrated learning experiences during their studies as pharmacy practice courses, where they are expected to work under supervision in real pharmacy settings for short periods. However, no minimum or maximum hours of experiential practice are required in the accreditation standards. Because of budget limitations and a lack of suitable educational community pharmacies, students have few opportunities to interact efficiently with patients in a realistic pharmacy environment. Hence, it is essential to ensure that students are given supplementary training to complement and better prepare them for their practice experiences to gain maximum educational value from their limited time.

Considering all of what was described, in the present study, we aimed to develop a virtual simulation that allows pharmacy students to play through actual prescriptions and pharmacy practice scenarios productively and engagingly on a personal computer. If designed properly, this program may serve as a supplementary educational tool without the need for an existing human tutor that could provide learning outcomes as good as those resulting from traditional paper-based pharmacy practice tutorials. Once sufficient banks of scenarios are written, we believe this simulator will be able to augment existing teaching activities throughout the degree at our school and nationally.

METHODS

This project was approved by the National Agency of Strategic Research in Medical Education, affiliated with the Iranian Ministry of Health and Medical Education (project number: 960385), and performed with the collaboration of Virtual Education Center and School of Pharmacy, affiliated to Isfahan University of Medical Sciences, Isfahan, Iran, since February 2019 till January 2021.

A computer-based simulation of a community pharmacy was developed. The development of this virtual pharmacy was a team effort. The original development team comprises a project manager, five senior pharmacy students, an academic clinical pharmacist consultant, two developers with database and web programming skills, and a graphic interface designer. Once designing decisions were finalized, technical platform specifications were determined.

A phased approach to software delivery was planned to deliver a functional program in a short timeframe rapidly; future versions with increased functionality were scheduled for later deployment. Since this web-based program was considered mainly for Iranian pharmacy educational purposes, it was designed in Persian. We tried this simulation to be highly detailed and customizable to what is seen in Iranian pharmacies.

This program mainly targeted three basic learning needs of pharmacy students: drug dispensing, patient counseling, and dealing with clinical situations related to the patients' prescription or demand for over-the-counter (OTC) recommendations. For the first educational purpose, fundamental design decisions were based on breaking down the dispensing process into logical components (e.g., focusing on the patient's information, reading the whole prescription, producing an invoice containing all the prescription drugs, selecting the product, and finalizing the medication package) to provide discrete development elements.

The dispensing logic determined the sequence of processes necessary to issue an item. For example, a product may only be selected after the prescription has been completely read and converted to an invoice. The discrimination required to progress through an exercise encourages self-regulation and awareness of the stages and skills employed at each process step. To educate students that they need to observe both the accuracy and speed of action in the field, we considered a time limit for completing each defined activity. At the end of each practice, the time spent by the students to deal with, and the probable mistakes they made, will be shown.

As accurate product selection is vital to dispensing, relatively high engineering fidelity was used to display products as they would typically be encountered in a pharmacy, including different dosages and dosage forms of each medication. After enough images were taken, a preview and thumbnail view with defined dimension and resolution were created for over 2000 individually photographed products. The medicine information selection field was then populated for these products using actual data retrieved from a documented drug information database (https://reference.medscape.com).

This software had two primary views: the student view, to deliver exercises and assessments; the instructor/administrative interface, for teachers or admins to build and manage activities, create student groups, supervise students, and create assessable exercises.

In the administrative interface view, exercises were constructed to connect patient, prescription, and medication individually, for which feedback was then created. Then, the whole exercise was allocated to a tutorial. Also in this interface, the internal data such as prescriptions, clinical scenarios, and medications can be managed.

In the student view, students engage in various activities involved in dispensing medicines by completing exercises. Patient-centered exercises represent the process from receiving a prescription to handing the medicine to the patient. Exercises were restricted to specific activity subsets consistent with the course curriculum and student proficiency. During exercises, students see virtual representations of patients, prescriptions, and products on shelves. The software elements in the student view consist of the dispensary [Figure 1], the product selection system where students retrieve medicines for dispensing, the drugs themselves, and patient and prescriber fact-finding, which allows prescription processing, patient information review, and presenting drug information needed for patient's counseling related to the prescription.

Figure 1: A screenshot of the dispensary environment designed for the student's interface (in Persian language)

For teaching patient counseling and clinical skills, instructors wrote scenarios covering the most prevalent pharmacy practice issues, mainly focused on medication use during pregnancy or lactation, OTC recommendations, information related to drug interactions and adverse drug reactions, and interactions between prescription drugs and patient's underlying disease. In addition, a time limit was considered for completing each clinical scenario. The educator considered all relevant patient details, all the dialog options that should be available in each section, which were designed in the form of right/wrong branches of a whole tree, the scores and associated feedback, besides selected events that occur when certain medications or classes of drugs are provided, or when a specific score or time threshold is broken.

The software featured: web-based access for use in the classroom and outside it; protection by an authentication system; the ability to populate student and staff accounts through simple data files; a hierarchical structure of units, tutorials, and exercises; various user roles such as student, instructor, and administrator; ability to group students for teaching and assessment purpose; facility to deliver assessments; and time-based release of tutorials and examinations.

All a student needs to participate is access to a computer or a tablet-like device. Students take on the pharmacist role in this virtual community pharmacy. They are given complete freedom to walk around all areas of the pharmacy and make context-appropriate interactions with relevant items, such as the products on the shelves, the dispensing computer, plenty of prescription samples, and the clinical OTC or prescription-based scenarios presented to the pharmacist.

The following open-source and standards-based technologies were used: CSS for styling; JQuery JavaScript library for graphic effects on the browser; PHP for server-side coding; and a cake PHP framework for rapid code creation; HTML and JavaScript for client-side coding; JavaScript Object Notation (JSON) for data interchange; and Asynchronous JavaScript and

XML (Ajax) for communication with the server that does not interrupt the current browser display.

RESULTS

This program was designed as simulated learning and teaching environment to help students develop skills and competency at a level of detail and difficulty corresponding to their knowledge and experience. Tutorials, including screenshots of the software, are available on its website (https://www.vpharm.ir/).

Based on the primary curriculum topics, the development team designed exercises for pharmacy practice courses presented to year-5 pharmacy students, semesters 1 and 2. The tutorials formed part of the teaching activities of the final-year pharmacy practice units. Accordingly, activities were developed based on dispensing a prescription to accomplish learning outcomes. To fulfill this part, over 2000 real prescriptions were scanned and categorized based on the main drugs included. These prescriptions were used for both activities, namely medication dispensing and clinical scenarios.

Tutorial sessions with multiple exercises were designed and programmed to be delivered approximately every week during two final semesters, structured around a step-by-step guide to help students develop skills in safe dispensing a prescription. Activities required students to dispense essential prescriptions, as would be processed in a typical community pharmacy setting, focused on variation within a single element of the dispensing process, such as correctly reading the whole parts of a legally written prescription, producing a relevant invoice, dispensing medication dosage forms, and eventually providing and interpreting basic medication information for the assumptive patient. The mentioned steps only can proceed, respectively; for example, the students should check that the generated invoice matches the whole medication box they picked up (and the relevant prescription details) and then continue the dispensing process. At the end of each semester, students took a dispensing examination on this software accordingly, which contributed 25% toward their semester grade.

Also, for teaching patient counseling and clinical skills, which are expected to be comprehensively learned by pharmacy students, more than 200 clinical scenarios were written by five senior pharmacy students under a clinical pharmacist's supervision, to ensure that scenarios are relevant, up-to-date, and adequately address current learning objectives. The main objectives of pharmacy practice courses were followed to cover the most important must-to-know clinical tips, whether related to giving relevant advice as an OTC recommendation,

referring the patient to a primary care physician, or just providing a piece of general health advice.

The clinical scenario exercises were developed to authentically reflect tasks and challenges a community pharmacist would regularly face in the workplace. These encourage students to learn by making mistakes, knowing they can fail in a safe learning environment.

To start a session, the student can choose one from a bank of prewritten scenarios. When they have selected which scenarios they want to go through, a virtual patient's pertaining prescription or medical history will be shown. The student can then interact with the scenario trip via responding to consecutive multiple-choice questions, which guide the student to deal with a comprehensive clinical situation leading the virtual patient to a piece of proper advice. Conversations with the patient are typically broken up into three phases or groups: (1) opening questions, where the student ascertains the purpose of the pharmacy visit, and what the patient wants; (2) history taking, where the student can choose the right question to ascertain the appropriate course of action; and (3) recommendations, where the student can provide counseling advice to the patient.

The student only can select these conversation phases, respectively. Selecting a phase brings up the currently available dialog options for that phase, which were previously designed by the developing team. When the student selects dialog options, it typically results in a text response from the patient. A screenshot showing the dialog system is provided in Figure 2.

Initially, the student faces opening questions to determine why the patient refers to the pharmacy. Thus, the student would typically ascertain what the patients' complaint is and whether they have a prescription or not. After this, the student asks questions to determine precisely what the patient needs and whether other problems need to be addressed. Once the student determines the appropriate course of action, a suitable recommendation can be selected from the range of options: give relevant advice
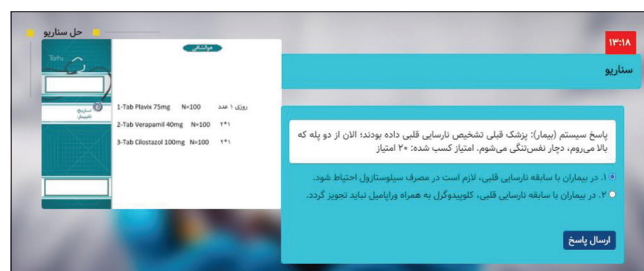

Figure 2: A screenshot of the software environment showing the "question" dialog menu for a presumptive clinical scenario (in the Persian language)

as an OTC recommendation, refer the patient to their primary care physician, provide a product, or do nothing.

If the student decides to provide a product, they must retrieve it from the store shelves through the dispensing process. After choosing the phase, a dispensing interface displays on the screen. The student can then search for and select the product they wish to dispense from the product database. To help students locate the products in the crowded dispensary, the products are categorized based on dosage forms, which are retrievable alphabetically by typing the first letters of the product, in each category.

Once the student has finished selecting the right product, they can approach the patient with the items. At this stage, the student typically provides advice about correctly using the product and/or monitoring symptoms, by choosing the relevant phrase from multiple choices. Once the student completes the scenario to their satisfaction, the scenario ends.

At this point, the scenario scorecard appears, providing feedback on why every action the student took was appropriate or not, and giving a score. The student's total score is shown, and a percentage score, so the student knows how much distance to complete success there is.

To support individual development, students will receive immediate rich contextual feedback about their mistakes, the time spent fulfilling the activity, and the tutorial tips related to the prescription, or clinical scenario, when an exercise is completed. A "Do Again" button also appears at the end of each exercise on the students' interface, and those who are dissatisfied with their scores are encouraged to repeat the activity to promote beginner-level competency. However, this button was removed from the interface considered for the final examination.

DISCUSSION

In the pharmacy curriculum, there is a need for clinical and practical training in some areas (e.g., community pharmacy practice courses), while the implementation is faced with limited time and space for the sessions, because student numbers are growing, and the cost of providing placements is high.

Pharmacy practice courses let pharmacy students be in touch with patients and enable them to give advice and practice good patient education. The aim is to ensure the proper use of medications, prevent drug side effects, practice evidence-based use of drugs, and provide patients with information about the appropriate use of their medications.[13,14] However, the pharmacy practice competencies require students to identify clinical and legal errors on a prescription, and then dispense it in

a safe learning environment. Hence, it is more logical if e-learning is used in conjunction with face-to-face teaching since it is becoming increasingly challenging to provide an adequate number of placements for enough education for each student.

Blended learning is being used worldwide and has improved pharmacy students' knowledge, skills, and confidence. One sound education system is through computer-assisted learning, which encourages students to use computer technology, resulting in active and independent self-learning. It is believed that using computer simulations improves understanding based on practical problem-solving and broadens students' experience of establishing contact with patients.[15-17]

Due to the importance of pharmacy practice courses, a virtual technology for educating the students in this area is beneficial. This program should be designed as much similar and practical as real pharmacy environments dedicated to in-site training, to improve their knowledge and confidence.

Several studies have shown that applying the virtual education program increases pharmacists' knowledge.[18,19] In one study, the students were assigned to two groups. Group 1 was taught using lectures (conventional method), and Group 2 received a combination of lectures and virtual patient simulation. The final scores of the two groups showed that Group 2 had more improved problem-solving skills than Group 1.[20] The European Union started using this technology in 2000, and at present, it has expanded across the union.[21-23]

As in many other countries, community pharmacists in Iran perform various activities above and beyond dispensing medications. One of their most valuable services is performing clinical interventions, where they identify an actual or potential drug-related problem and take action to resolve it. For this purpose, the pharmacist must have extensive clinical knowledge of many issues and be sufficiently trained to see the problems. Simulated activities may provide the needed opportunity; however, there are no minimum or maximum simulation-hour requirements in Iranian accreditation standards.

The presented virtual program was designed as a simulated learning environment to help students develop prescription dispensing and clinical skills. This program uses real scenarios, and at the same time, it provides a safe environment for learning and leads to more confidence in pharmacy students. To be considered a success, this simulation needed to provide equivalent or better learning outcomes than the current practice approach, which should be assessed in the

future evaluation of the software, and then be promoted accordingly.

We considered it to be blended with in-site pharmacy practice education and make the opportunity for our educational system to benefit from the advantages of both styles. However, it should always be borne in mind that the quality of face-to-face education is undeniable in many aspects, and should not be replaced totally with the virtual methods, even if designed as much similar to the real ones.

Authors' Contribution

A. Najimi managed the whole project regarding engineering integration. S. Badri supervised all the scientific aspects as a clinical pharmacist. M. Azizkhani, S. Zolghadr, S. Roofeh, S. A. Sepehr, and S. Mohammadi contributed to all practical activities as senior pharmacy students.

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Conflicts of interest

There are no conflicts of interest.

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