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A Computer-Based Tutor to Teach Nursing Trauma Care That Works as an Adjunct to High Fidelity Simulation

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Abstract

Educators are challenged to prepare nurses to care for low-frequency, high-stakes problems such as trauma. Computer-based tutors provide a cost-effective teaching strategy without risking patient safety. Evidence for the efficacy of this type of instruction is limited; thus, we tested the learning outcomes of a tutor on trauma care knowledge with senior nursing students. Participants were randomly assigned to either the tutor or a control condition (textbook learning). Instructional design elements incorporated into the tutor included use of multimedia content, emphasis of key points, frequent quizzing with instant feedback, and unfolding case studies to summarize key concepts. Use of the tutor led to a larger increase in trauma nursing knowledge than use of a textbook. In addition, the knowledge was retained as well as book-based learning. The effect size of the tutor, 1.15, was relatively high, the average for computer tutors is 0.79. Qualitative focus groups revealed that participants expressed favorable views of the tutor in comparison to textbook learning. They found it more engaging, more enjoyable, and reported it effectively organized the content. The results of this study support the efficacy of a well-designed computer-based tutor for learning key concepts of trauma nursing.

Key words: *Computer-based tutor; nursing education; learning outcomes*

Introduction

Background

Nurse educators are challenged to prepare students to provide care for low-volume, high-acuity clinical problems. Care of the trauma patient is one such clinical problem. Trauma nursing is a highly specialized skill that is infrequently encountered in clinical practice. It is difficult to provide learners with hands-on practice without compromising the quality of patient care in such a time-critical situation. Lectures or textbook readings provide important background knowledge and theoretical content but may not be perceived as engaging by the learner and fail to provide an opportunity to proceduralize and apply the concepts being learned. The lack of available access to hands-on clinical instruction creates a need for alternate learning strategies. [1]

Manikin-based simulation and e-learning are potential alternative instructional strategies to traditional lecture, textbook, or observation-based clinical instruction. The use of high-fidelity simulators in nursing education is now well-accepted and supported by a growing body of empirical literature. [2, 3] While popular, simulation with high-fidelity manikins faces several disadvantages, such as requiring expensive equipment and being resource intensive to operate. [1, 4]

Computer-based tutors (CBTs), web-based modules, and virtual simulations are alternative e-learning strategies to textbook learning. This type of instruction has several advantages that include allowing mistakes on the path to mastering concepts without risk to a patient.[4-6] CBTs can incorporate important concepts from cognitive science and learning theory to enhance the effectiveness of learning. A CBT that is based on learning theory can encourage learners to engage with the material in a more ecologically meaningful way than a textbook and

can support learners, through exercises, to be actively involved in creating their own understanding of the key concepts.[1,7] Additional benefits of this type of instruction include that it enables the learner to work at their own pace, provides real-time feedback on performance, and offers the learner the opportunity to repeat the CBT until mastery of the content is achieved. [5,7,8] CBTs also allow for learning to occur without extensive direct faculty contact. [4, 6]

Literature Review

Despite the potential advantages of CBTs, there is limited evidence to support the efficacy of this type of instruction for health professionals. While several studies have compared CBTs to more traditional forms of instruction in both nursing and other disciplines, they have primarily relied on self-efficacy or satisfaction metrics. In these studies, learners reported positive perception of CBTs for discrete mathematics and web development training. [7,8] A study comparing CBT and manikin-based simulation for training nurses on cardiac arrest resuscitation found no difference in participant's self-efficacy or satisfaction between the two methods. [9] VanLehn (2011) conducted a systematic review that documented effective learning outcomes for a variety of types of CBTs[10], but most of these were science or mathematics topics rather than healthcare focused.

There have been a limited number of studies that found a positive impact of CBTs on learning outcomes in nursing or other health disciplines. Farra et al. compared the efficacy of web-based modules to web-based modules with virtual reality simulation (VRS) on learning and knowledge retention of disaster management for nursing students. They found that both groups demonstrated statistically significant knowledge gains after the training but the VRS group had significantly better retention at two months.[5] Hamm et al. compared textbook instruction to CBTs for teaching chest pain diagnosis to health professionals. They found that participants who

studied cases using a CBT, either alone or along with a textbook, learned more than participants who only studied the textbook.[6] Verkuyl et al. compared a virtual reality game to traditional high-fidelity simulation in a pediatric nursing course. The gaming group had slightly larger gains in knowledge. Both groups scored high for self-efficacy and satisfaction.[4]

Prior studies offer limited support for the efficacy of CBTs in instructing nursing or health professional students, but additional evidence is required if these types of tutorials are to be widely incorporated into nursing curricula. In addition, no studies were found that specifically evaluated the use of a CBT to teach trauma nursing. This study of a CBT for nursing care of trauma patients was designed to address these knowledge gaps.

Purpose

The purpose of this study was to evaluate the impact of a CBT teaching trauma nursing on student learning. The study objectives were as follows:

1. Compare knowledge acquisition between students who use a CBT to students who study the same concepts using a textbook.
2. Compare knowledge retention between students who use CBT to students who study the same concepts using a textbook.
3. Evaluate the learners' perception of the CBT in terms of ease of use, engagement, enjoyment, and effectiveness in facilitating learning as compared to using the textbook.

Methods

This study used an experimental, between subjects, pretest, posttest design. The research team tested the learning outcomes of a CBT on trauma care knowledge. We hypothesized that learners using a CBT would demonstrate larger gains in knowledge and better knowledge retention than those randomized to textbook learning. Textbook learning was selected as the

control condition because we were interested in studying alternatives to expensive high-fidelity simulation. Participants were randomly assigned to either the CBT on trauma nursing or a control condition (textbook learning). The control condition used sections from the *Trauma Nursing Core Course 7th ed.*,[11] that addressed concepts taught in the CBT. The concepts addressed in both the CBT and assigned readings are outlined in Table 1. The study was approved by the Institutional Review Board (IRB) at the university where the study was conducted. Participants provided informed consent prior to study enrollment.

Both groups completed the same pretest knowledge assessment on trauma nursing. Correct answers were not revealed. After completing the pretest, participants completed the learning activities at their own pace. Participants kept a log of time spent and number of tutor pages completed or textbook pages read. Upon completing the learning sessions, participants took the same test on trauma nursing as at pretest to assess knowledge gain. Participants also retook the test one month after the posttest.

In addition, a qualitative descriptive design was employed to elucidate participants' impression of their learning experience. Participants were asked to take part in semi-structured qualitative focus group interviews to describe their perceptions of the tutor or textbook learning. These interviews were audio recorded and transcribed verbatim for analysis.

CBT Characteristics

The CBT was designed to provide the learner with practice implementing and interpreting the primary and secondary trauma survey. The CBT was created using D2P (Declarative to Procedural), a tutoring architecture based on learning and cognitive science theories.[12] Concepts were presented to the learner using a variety of media including text, pictures, and video. Content was organized using an outline format that followed the steps of the primary and

secondary trauma survey. Key points were emphasized using bulleting or bolded text and the amount of text per screen was limited. The tutor included multi-question quizzes at the end of each section which provided immediate feedback on correct or incorrect answers with rationales. This provided the learner with in-time feedback and corrected erroneous thinking. The quiz questions included a variety of formats such as multiple choice, multiple select, matching, and ordering. In addition, questions that incorporated video and audio components to test the learners' ability to interpret relevant assessment findings were included. Video and audio quiz questions added variety to increase learner engagement and better mimic clinical reality. Unfolding case studies were used to summarize key learning points. Example pages from the CBT are shown in Figure 1. These engagement strategies were incorporated to allow learners to actively apply the content. This focus on active learning is supported by the ICAP theory of cognitive engagement which posits that active engagement with content result in superior learning outcomes than passive activities.[13] A concerted effort was made to chunk information into smaller units to help learners organize and digest the content. The tutor was reviewed by multiple subject matter experts, including trauma physicians and nurses, who contributed to its development through formative feedback.

CBT Development

The CBT was created in the D2P tutoring architecture which is based on cognitive science, human-computer interaction, and a learning theory.[12, 14] The CBT has 159 pages, including 22 pages of quiz questions. The quizzes include approximately 125 questions containing videos, images, and text-based material. A video illustrating the CBT can be viewed at http://acs.ist.psu.edu/projects/d2p/movies/AFTNC-DemoV6.mov. The tutor was created by a team consisting of a nursing professor, a cognitive scientist, a post-doctoral scholar, and two

undergraduate research assistants over a 6 month period that included further development of the tutoring architecture. The ADDIE instructional design process[15] was used to construct the CBT. We initially created a structured abstract, then drafted slides, then important the content into D2P. The nursing professor designed the material; the tutoring architecture was modified as necessary by the cognitive scientist and the post-doctoral scholar, and direct modifications to implement, modify, and debug the tutor were done by the undergraduate assistants.

Sample

The sample consisted of 35 senior-level students in a large baccalaureate nursing program. The mean age was 21.5 years and the sample was predominately female (91%) and white (89%). Table 2 provides a summarization of the demographic characteristics of this sample. A power analysis (G Power 3.1.9.2) indicated that a sample size of 34 would be required to detect a moderate effect size with a power of 80% using a p-value of .05.

Quantitative Measures

A 50-item test on trauma nursing concepts was constructed focusing on essential elements of the primary and secondary survey. The test was reviewed for content validity by two certified trauma nurses and revised based on their feedback.

Data Analysis

Independent sample t-tests were used to compare pre-test, learning gains, and knowledge retention between groups. Data analysis was performed using IBM SPSS Statistics 25.0 for Mac (IBM, Armonk, NY). Qualitative interview transcripts were analyzed using constant comparison to detect patterns in the data and identify codes.[16] The codes were further analyzed to determine themes.

Results

A total of 35 participants completed the pretest and were randomized. The randomization resulted in 19 in the CBT group and 16 in the control (textbook) group. There was no difference in baseline knowledge, as measured by number of questions answered correctly, at pretest for the CBT group (M = 26.7, SD = 3.8) and the control group (M = 28, SD = 3.4); t(33) = -0.97, p = .34. Thirty four participants completed their assigned learning activity and the posttest. The groups were also compared for time on task. There was no difference between the CBT group (M = 4.7 hours, SD = 2.44) and control group (M = 4.1 hours, SD = 1.49); t(29) = 0.772, p = .446.

Learning Outcomes

Learning gains were calculated by subtracting each learner's pretest score from their posttest score. CBT participants (M = 7.4, SD = 3.36) improved their scores by a significantly larger amount, approximately 100%, than control participants (M = 3.7, SD = 3.0); t(32) = 3.3, p =.002. The effect size for the CBT was 1.15, which was above the average of 0.79 for computer tutors.[10] A total of 26 participants completed the one month posttest. Posttest learning retention was calculated by subtracting each learner's posttest score from their one-month posttest score. The one-month posttest was taken by 26 participants. There was no reliable difference in knowledge retention between CBT participants (M = -0.5, SD = 3.41) and the control group (M = -1.6, SD = 2.88); t(24) = -.85, p = .405. Learning outcome results are summarized in Table 3.

Learner Perceptions

Focus groups using a semi-structured interview guide (see Table 4) were conducted with learners to determine learners' perception about the assigned method of instruction. Ten learners from the CBT group and nine learners from the textbook group participated in separate focus

groups.

Themes that emerged from the CBT focus group included learner engagement, efficacy of quizzing, appeal of multimedia materials, and effective organization of content. Learners found the interactive aspects of the CBT engaging, and it held their interest. They found the quizzing was one of the most useful features of the CBT. They felt that it evaluated recall of information, reinforced their learning, and helped to correct mistakes in their thinking. Learners reported that they liked the inclusion of video and audio content in addition to text. They felt that the tutor structure helped them organize the information and did a good job of highlighting key points.

Themes that emerged from the textbook focus group included that they found this method of instruction not to be effective. They felt that the book contained important information but did not promote learning. Themes identified in this group included a lack of engagement, feeling overwhelmed with information, and wanting more variety. Learners reported that they did not feel engaged and had difficulty paying attention. They found that the amount of information presented in the text was overwhelming and that the textbook did not effectively organize the information or help them to prioritize key points as we sought to do in the CBT. They would have preferred to have audio and video content as well as practice questions. Learners did note that an advantage of the textbook was that they prefer to read printed text rather than a computer screen. They also noted the textbook incorporated helpful graphics, charts, and acronyms.

Discussion

This study compared learning outcomes and learner perceptions between students randomized to a CBT on trauma nursing and those randomized to a textbook covering the same topics. The CBT led to a larger increase in knowledge than the textbook. Although there was not a significant difference in knowledge retention, the knowledge gains in the CBT group were

effectively maintained. The effect size of the CBT, 1.15, was relatively high as well. These results provide evidence that CBTs can be an effective adjunct to traditional instruction if key instructional design elements are incorporated into the tutor. Instructional design elements incorporated into this tutor included use of multimedia content, emphasis of key points, frequent quizzing with instant feedback, and unfolding case studies to summarize key concepts. In addition, this type of tutor could be used to prepare learners for expensive high-fidelity simulations.

Participants expressed favorable views of the tutor in comparison to textbook learning. They found it more engaging and enjoyable. Keeping modern students engaged remains challenging. Learners born after 1990 read less than previous generations and have shorter attention spans.[17] The findings from this study support the idea that students find technology platforms more engaging than textbooks. The frequent quizzes were perceived to reinforce learning and retention.

Learners reported that the tutor was more effective in organizing information. Chunking is a well-accepted learning strategy that enables the learner to organize large amounts of new information into fewer units of meaning.[18] Chunking prevents cognitive overload and enables better utilization of short-term memory when learning new concepts.[19] Chunking has also been suggested as an effective cognitive strategy for mastering complex nursing content like pharmacology.[20] Things that were done to facilitate chunking included: hierarchical task analysis, overviews of tasks and sections, reinforcement through quizzes, and unfolding case studies that summarize skills. Our findings support the theory that designing a tutor that helps learners organize and chunk complex content can be effective for other clinical topics like trauma care.

Although learner satisfaction and perception of improved learning do not necessarily

translate to quantifiable knowledge gains, quantifiable knowledge gains were demonstrated in this study. The findings of this study need to be interpreted cautiously due to limitations including a relatively small sample size and use of a single site to collect data. Despite these limitations, our findings add support to prior findings that CBTs are effective for knowledge acquisition and are found to be engaging and enjoyable by learners.

One potential extension of this work is to include a virtual simulation within the tutor. This would increase the opportunities for learners to engage with and apply the material. Chi, in the ICAP theory of cognitive engagement, proposes a taxonomy of learning activities in which increased engagement with the material improves learning outcomes.[13,21] In this theory, learner behaviors are ordered from the least effective to the most effective as follows: passive is less effective than active, which is less effective than constructive, which is less effective than interactive. Passive activities would include listening to a lecture or reading a text without taking any other actions. Active activities involve having to take some action with material like answering questions. Constructive activities involve producing something beyond the material as presented or applying it in a novel context. Interactive activities involve engaging with the material with another person and co-creating an understanding of the concepts. Our findings support Chi's theory that active activities produce superior learning outcomes than passive activities. Incorporating a simulation into the tutor would move the learning activities from active to constructive and has the potential to produce even more effective outcomes. Interacting with a virtual simulation may be another way to proceduralize the skills.

The results of this study support the efficacy of a well-designed CBT for learning key concepts of trauma nursing. Additional research with a larger sample is planned to evaluate if incorporating a virtual simulation will further improve learning gains and/or knowledge

retention.

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Figure

D2P Trauma Nurse Course

Figure 1: Examples of Tutor Content

Example Tutor Content

Prioritization Using <C> ABC

Research has indicated that uncontrolled hemorrhage is the leading cause of preventable death for trauma patients.

Military clinicians have adapted priorities in the case of uncontrolled hemorrhage to <C> ABC.

Evidence-based practice is now to address uncontrolled hemorrhage before going on to assess the ABCs.

Section 3: Primary survey (ABCDE)

The goal of the primary survey is to identify life-threatening situations and rapidly intervene. The elements assessed during the primary survey include:

- A- **A**irway and **A**lertness with simultaneous cervical spinal stabilization
- B- **B**reathing and ventilation
- C- **C**irculation and **C**ontrol of hemorrhage
- D- **D**isability (neurologic status)
- E- **E**xposure and **E**nvironmental control

Example Video Quiz

6. LOC 6

6.1 What is this patient's Level of Consciousness?:
Your answer of *Unconscious* was correct.

Example Text Quiz Question

5. Disaster Triage 1.3

The nurse is triaging victims of a mass casualty incident. Determine which category would be assigned to each patient.

5.1 The patient was in a building explosion and is alert and oriented, has singed nasal hair and a respiratory rate of 32, and has a palpable radial pulse with capillary refill of 2 seconds?:
Your answer of *Red (Immediate)* was correct.

Instructor feedback:

The data indicate that there is an acute risk of airway compromise and breathing difficulty, possibly due to inhalation of smoke or chemical fumes.

Example Unfolding Case Study

Review Scenario #1

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A 30 year-old male is brought in after sustaining a blast injury when an IED exploded next to the vehicle he was driving. He was ejected from the vehicle. His cervical spine was immobilized at the scene. An across the room observation reveals an unresponsive victim with no obvious external hemorrhage.

What action should the nurse take next? Decide and then go forward a page.

Review Scenario #1 (continued)

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The nurse should open and inspect the airway using the jaw thrust maneuver.

While assessing the airway, the nurse notes that the tongue is intermittently falling back and obstructing the airway. There are no foreign bodies, blood, or vomitus in the mouth. Once the airway is opened, no stridor or gurgling is he

What action should the nurse take next? Decide and then go forward a page.

Table

Table 1 Concepts Covered in Tutor/ Reading Assignments

- MIST Prehospital Report
- Triage Categories and Disaster Triage
- Components of the Primary Survey
    - <c>ABCDE
        - Control Massive Hemorrhage
        - Airway
        - Breathing
        - Circulation
        - Disability
        - Exposure
- Cervical Spine Stabilization
- Details of Airway Management
    - Assessment for Airway Patency
    - Sources of Airway Obstruction
    - AVPU Assessment for Level of Consciousness
    - Airway Adjuncts
    - Indications for Immediate Intubation
- Details of Breathing/Ventilation
    - Assessment of Breathing
    - Indications of Inadequate Breathing or Oxygenation
    - Oxygen Delivery Decisions
    - Management of Thoracic Injuries
        - Open Pneumothorax
        - Tension Pneumothorax
        - Flail Chest
    - Rapid Sequence Intubation (RSI)
- Details of Circulation
    - Assessment for Signs/Symptoms of Shock
    - Types and Stages of Shock
    - Control of Bleeding
    - Estimated Blood Loss
    - Fluid Resuscitation Guidelines
    - Assessment and Management of Cardiac Tamponade
- Details of Disability/Neurological
    - Assessment of Head Trauma
    - Assessment of Glasgow Coma Scale (GCS)
    - Pupil Assessment
    - Assessment for Basilar Skull Fracture
    - Indications for Head CT
- Exposure
    - Remove all Clothing to Assess for Injuries
    - Warming Methods
- Components of the Secondary Survey
    - Family Presence
    - History
    - Vital Signs
    - Laboratory Studies
    - Resuscitation Adjuncts
    - Head to Toe Assessment

Table

Table 2 Sample Demographics

Variable		CBT group (n =19)	Control group (n =16)	Total sample (n = 35)
Age		21.6	21.3	21.5
Gender	Female	17 (89.5%)	15 (93.8%)	32 (91.4%)
	Male	2 (10.5%)	1 (6.3%)	3 (8.6%)
Ethnicity	White	18 (94.7%)	13 (81.3%)	31 (88.6%)
	Asian	1 (5.3%)	1 (6.3%)	2 (5.7%)
	Hispanic		1 (6.3%)	1 (2.9%)
	Mixed		1 (6.3%)	1 (2.9%)

Table

Table 3 Learning Outcomes

	Group	***n***	***m***	**SD**	**Difference**	***t***	***p***
Pretest	CBT	19	26.7	3.8	1.3	*t*(33) -0.97	.34
	Book	16	28	3.4			
Knowledge Gain	CBT	19	7.4	3.36	3.7	*t*(32) 3.3	**.002**
	Book	15	3.7	3.0			
Month Knowledge Retention	CBT	16	-0.5	3.41	1.1	*t*(24) -0.85	.405
	Book	10	-1.6	2.88			

Table 4 Qualitative Interview Guide

Thank you for participating in the focus group. We appreciate your input. We are interested in hearing about your experience in using the tutor/book to learn the trauma nursing content.

1. Describe your overall impressions of learning the content using the tutor/textbook
2. What about this method of instruction did you find most helpful?
3. How could this method of instruction be improved?
4. Did you find this method of instruction enjoyable? If so in what way?
5. Describe the degree to which you found this an engaging way to learn
6. Describe any difficulties you had using the tutor/textbook to learn the content
7. Did this method of instruction appeal to your individual learning styles and preferences? Why or why not?
8. Describe any difficulties or challenges that you encountered using this instruction method
9. Was this method of instruction effective in helping you master concepts of trauma nursing? Why or why not?
10. What are the advantages and disadvantages of this method of instruction?
11. Anything else that you would like to share regarding your experience with the tutor/textbook learning?