INSTRUCTIONAL DESIGN AND ASSESSMENT

Case-based Assessment in an Online Nursing Pharmacotherapy Course

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Objective. To implement and evaluate the effectiveness of case-based assessments in an online pharmacotherapy course for nursing students.

Design. Four case-based examinations developed in parallel for the midterm and final examinations and designed to address potential barriers to maintaining academic integrity were compared.

Assessment. The use of online, case-based assessments was successful in providing 4 parallel examinations that assessed case-based decision making while maintaining academic integrity and minimizing instructor grading burden.

Conclusions. Using an online, case-based assessment strategy is effective and feasible for evaluating the clinical application knowledge of nursing students enrolled in a pharmacotherapy course.

Keywords: nursing, pharmacotherapy, case-based design, multiple-choice examinations, assessment, Internet

INTRODUCTION

Pharmacotherapy is a complex topic that requires several years of study in both classroom and experiential contexts for pharmacy students to master. Other health professional training/degree programs often limit pharmacotherapy education to 1 semester or term. Because of their expertise in pharmacotherapy, pharmacy educators often are asked to teach the pharmacotherapy component of the curriculum within other health professional programs. Comprehensively covering the wide range of topics within the field and tailoring the content to a particular health professional audience presents significant challenges for the instructor. Increasingly, pharmacotherapy courses in nonpharmacy health professional programs are offered online, which adds a further challenge to creating a meaningful, yet manageable, educational experience.

Within health professional programs, a variety of related educational strategies are used to provide authentic learning opportunities, such as case-based, anchored, problem-based, project-based, and cognitive apprenticeship instruction.¹ Teaching cases, an active-learning strategy commonly used in health professional education, are used to expose students to important and common patient situations that have no definitive correct solution. The use of teaching cases is based on the premise that learning

from a specific case discussed in the classroom can be transferred to an actual patient encounter in practice, and that exposure to teaching cases helps students to develop the complex skills and flexible thinking needed to adequately manage novel patient cases.² But effective use of case-based strategies requires a lot of instructor time and effort and careful development and planning.¹ For this reason, case studies often are not used in high enrollment courses, even though this strategy is recognized as an important tool for building clinical competency.¹

Case-based reasoning agrees with a constructivism position that students must create their own understanding within a situated learning experience.³ Through case-based design, the goal is to create learning opportunities that require active engagement of the learner; the learner is given opportunities to infer and apply judgment, and to detect similarities and differences between situations.³ The ultimate goal is that students develop reasoning skills that can be transferred to patient situations later encountered in practice. The story aspect of case-based learning reinforces the idea of treating the whole patient, and recognizes that the patient's lifestyle as well as social and work history can impact treatment decisions and success.³

Transfer of knowledge, "the ability to extend what has been learned in one context to new contexts,"^{2(p51)} is a complex area of cognitive science, but in health professional education generally refers to the transfer of knowledge from a course to a real-life situation. Because every possible patient scenario cannot be taught, transfer is a primary skill for health professionals and the ability to transfer determines clinical competency.² Transfer requires that content knowledge not be overly situational and

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be learned in a meaningful way, allowing students to personally construct their knowledge and self-assess their learning. While disagreements in the literature concerning transfer is outside the scope of this manuscript, the importance for health professional educators to consider the goal of knowledge transfer in the design of educational activities and assessments is noteworthy.

As more health professional programs explore distance education formats, the challenges of providing engaging activities to a student audience separated from instructors and fellow classmates by distance and time is further complicated by high enrollment numbers. While synchronous distance activities are an option, they too, have their challenges, including: finding a specific time when all members of a course or group can participate; making adjustments for students who are not able to attend the synchronous event due to illness, technology issues, etc; dedicating the additional instructor time and effort that synchronous events require; and navigating through/maintaining continuity during the often disjointed discussion that occurs within a synchronous event (eg, different typing speeds, side conversations).⁴

Since 2004, the University of Minnesota College of Pharmacy has offered an online pharmacotherapy course to students in the bachelor of science in nursing degree program; in 2007, a graduate level pharmacotherapy course was offered to students in the master of nursing degree program. Teaching pharmacotherapy online and outside of the context of the pharmacy profession can be challenging. One complaint consistently mentioned in course evaluations was that the overwhelming amount of content covered in the course was too much to learn in 1 semester. While students have traditionally performed well (primarily A's and B's), there was concern among students and instructors that the volume of content was too great and that students were not retaining the information and thus not able to transfer their knowledge to practice after the course concluded.

The objectives of this study were to develop and evaluate a case-based approach to learning materials and assessment for an online pharmacotherapy course for nursing students; a design to foster in-depth understanding of common clinical scenarios and to facilitate transfer of reasoning skills to novel patient situations encountered in practice. The primary goal of this study was to design case-based assessments in the course, structured in a way that did not require synchronous course activities or individualized grader time and effort. The assessments aimed to address potential barriers to maintaining academic integrity, by using multiple parallel assessments that would perform equivalently. The use of case-based assessments and a transfer learning activity also were informally evaluated in this study.

DESIGN

In 2009, the instructional team redesigned the course, significantly decreasing the amount of content within the course and focusing it on the most common pharmacotherapy scenarios encountered by nurses within the ambulatory practice setting. Eleven nurses were interviewed to gain their perspective on the most relevant topics in the ambulatory practice setting. The nurses were given a list of previously covered topics in the course and asked to choose the areas and conditions most commonly encountered in practice. They also were asked which aspects of drug therapy were most critical to know (eg, mechanism of action, adverse effects, administration, monitoring, drug interactions, etc). The nurses' comments were combined with the firsthand experience of the primary course director, a pharmacist who practices in a family medicine ambulatory care clinic, and the past experiences of instructional team members with teaching pharmacotherapy to nursing students. From this input, a list of pharmacotherapy topics was generated and shared with nursing program faculty members who made suggestions about what should be covered in the course.

Reducing the number of topics covered in the course allowed each to be covered in greater depth, with the intention that solid content knowledge and extensive practice making clinical judgments within those disease/condition areas would foster the transfer of knowledge and clinical skills to future novel patient scenarios. The course learning materials were presented in a case-scenario format – students “followed” 2 patients, a man and a woman, throughout each learning module. The patients in the scenarios in subsequent modules continued to develop conditions as the semester progressed. By the final module of the course, both patients had a complex combination of medication conditions and therapies. Evaluation of the redesign using the new assessment strategy was performed in spring 2010, during the second offering of the course.

Four Parallel Case-based Multiple-Choice Examinations

Prior to fall 2009, assessment in the online pharmacotherapy courses were performed using computer-based examinations, administered in a proctored environment. Average enrollment per semester for the undergraduate course was 64 students and for the graduate course was 49 students. Because total enrollment for the 2 courses was 113 students, the proctored examinations created several logistical challenges. Also, the online courses were offered to students at 2 campuses, Twin Cities and Rochester, so proctors and testing rooms for midterm and final examinations needed to be arranged on both campuses, and

examinations had to be scheduled around times when the nursing students did not have other course obligations. Because of these challenges, a new assessment strategy that could be administered online was developed that would, at the same time, maintain academic integrity.

Four case-based examinations were developed for the midterm and final examinations in the 2 courses by the primary course director. The case-based structure of the examinations mirrored the case-based structure of the learning materials. The senior course director reviewed each examination for quality of content and consistency. These assessments were first administered in fall 2009. Students were randomly assigned to 1 of 4 examination groups for both the midterm examination (week 9) and the final examination (week 16). The examinations were delivered via the course management system, WebVista. Students were given a 10-hour window in which they could access the examination only once. Students taking the examinations in fall 2009 were given 60 minutes to complete the test, and after a review of student performance and time spent on each item, students taking the

examination in spring 2011 were given 45 minutes. The printing command in WebVista was disabled to discourage students from sharing the content with peers. Students were allowed to consult class notes if time permitted, but not allowed to consult classmates. Students were required to sign an honor code statement at the end of each examination indicating that they had worked independently.

Each midterm and final examination was based on a patient case that paralleled patient cases used in the course content. Twenty questions assessed key pharmacotherapy concepts on a variety of medical conditions. Drug information concepts also were assessed. The midterm examination covered learning materials from the first 3 modules. The final examination was comprehensive, with an emphasis on the medical conditions covered in the fourth and fifth modules. Table 1 shows the content for the course.

Each version of the examination was completed before work on the subsequent version began, ie, examination version A was completed before starting work on version B, and so on. Questions and concepts from the previous version of the examination were revised to fit the

Table 1. Content of an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

Modules	Topics Covered	Drug Information Activity Topic
Module 1: Background/Tools for the Course	Regulation of Medications Medication Disposal Drug Information Basic Pharmacology Drug Effects and Adverse Drug Reactions Calculations	Package Inserts
Module 2: Infectious Disease and the Respiratory System	Overview of Antibiotics Asthma & Chronic Obstructive Pulmonary Disease Smoking Cessation Vaccinations & Immunizations	Vaccinations
Module 3: The Central Nervous System	Depression & Anxiety Pain Management Constipation Contraception Insomnia & Sleep Hygiene	Alzheimer's Disease
Module 4: The Cardiovascular System	Hypertension & Heart Failure Dyslipidemia Anticoagulation	Herbal Products
Module 5: The Endocrine System	Diabetes Osteoporosis	Hypothyroidism

patient case in the subsequent version of the examination. As ideas for questions for subsequent versions of the examinations emerged, a list was started. All examination items were created using established best practices for multiple-choice question writing.⁵ A chart was created to tabulate the concepts and topics covered in each examination version. For example, each midterm examination version had 1 question on vaccinations, dose calculations, generic medications, drug information resources, inhaler technique, etc. Each midterm examination version had 2 questions related to pain management, depression, smoking cessation, etc. The chart also included parallel representation for each of the modules included in the examination; each midterm examination had 6 questions from module 1 content, 7 to 9 questions from module 2 content, and 5 to 7 questions from module 3 content. Table 2 provides an example of a parallel question used in each of the 4 versions of the midterm examination, related to the concept of administration of smoking cessation agents.

These examples all assessed a similar concept, but required construction of 4 different questions. Table 3 provides an example of a parallel question used in the final examinations that required only minor revision to fit the patient cases of the other examination version without constructing an entirely new question.

Tables 2 and 3 provide only the question and answer choice options. In the actual examinations, however, all questions included feedback as to why the correct answer was correct and the others choices were incorrect.

Drug Information Activities

One of the primary roles of nurses is providing patient education. Because this is an important skill related to pharmacotherapy issues, drug information activities used in another health professional pharmacotherapy course were adapted to allow nursing students to practice and master drug information retrieval, evaluation, and communication to patients. The drug information assignments also used a case-based scenario where the students

Table 2. Example Parallel Question From Each Version of the Midterm Examinations in an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

Midterm A. Nicotine gum administration	Midterm B. Nicotine lozenge administration
Jason returns to the clinic to follow up after his pneumonia resolved. Given this infection and his asthma, Jason decides it is finally time to quit smoking. He has been trying to slowly cut back on the number of cigarettes he smokes each day, but is struggling with cravings. He is interested in trying nicotine gum. Which of the following would you include in your patient education to Jason on how to use nicotine gum?	Lisa also reports increased chest tightness and coughing. Upon further questioning, you discover she recently started smoking. She is currently smoking 3 or 4 cigarettes a day. You provide Lisa with some behavior modification techniques. To cope with cravings, Lisa is going to use the nicotine lozenge. Which of the following would you include in your patient education to Lisa on how to use nicotine lozenges?
<ul style="list-style-type: none"> a. chew gum quickly for 20 minutes b. park gum only on one side of his mouth c. drink a glass of juice before using d. stop chewing at sign of peppery taste^a 	<ul style="list-style-type: none"> a. aggressively suck on lozenges to release nicotine b. do not rotate lozenges around the mouth c. use multiple lozenges to get maximum benefit d. avoid food or drink before using lozenges^a
Midterm C. Nicotine patch administration	Midterm D. Nicotine patch administration
Tom comes back to clinic a week later. He is having trouble keeping the patch on his skin. He is also having mild skin irritation with the patch. What do you tell him to do?	Phyllis is smoking a little over half a pack a day. She reports struggling with cravings and wishes to use the nicotine patch to help her quit. She has used it in the past and was successful. You review how to use it. Which of the following do you tell her regarding the nicotine patch?
<ul style="list-style-type: none"> a. apply lotion before applying the patch b. do not let the patch be exposed to water c. switch to a different brand of the nicotine patch^a d. place the patch on the same site every day 	<ul style="list-style-type: none"> a. apply lotion before applying the patch b. do not smoke while using the patch^a c. place the patch on the same site every day d. do not wear the patch overnight

^a Correct answer.

Table 3. Example Parallel Question From Each Version of the Final Examinations in an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

Final A. Phenylephrine precaution	Final B. Phenylephrine precaution
Jennifer returns to clinic for an acute care visit. She is complaining of congestion, headache and a cough. She is wondering about taking something over the counter (OTC) to alleviate her cold symptoms. She picked up a product that contains phenylephrine. Which of her medical conditions is a precaution to use with phenylephrine?	Randy returns to clinic for an acute care visit. He is complaining of congestion, headache and a cough. He is wondering about taking something over-the-counter (OTC) to alleviate his cold symptoms. He picked up a product that contains phenylephrine. Which of his medical conditions is a precaution to use with phenylephrine?
a. dyslipidemia b. hypertension ^a c. osteoporosis d. asthma	a. back pain b. COPD c. dyslipidemia d. hypertension ^a
Final C. Phenylephrine precaution	Final D. Phenylephrine precaution
Max returns to clinic for an acute care visit. He is complaining of congestion, headache and a cough. He is wondering about taking something over-the-counter (OTC) to alleviate his cold symptoms. He picked up a product that contains phenylephrine. Which of his medical conditions is a precaution to use with phenylephrine?	Sarah returns to clinic for an acute care visit. She is complaining of congestion, headache and a cough. She is wondering about taking something over the counter (OTC) to alleviate her cold symptoms. She picked up a product that contains phenylephrine. Which of her medical conditions is a precaution to use with phenylephrine?
a. asthma b. knee pain c. dyslipidemia d. hypertension ^a	a. COPD b. dyslipidemia c. hypertension ^a d. osteoporosis

^a Correct answer.

were asked to take on the role of the nurse and to research and communicate the answer to drug information questions. After finishing each activity, students completed a quiz. The first 4 drug information activities were more targeted in scope than the final activity and directed students to certain resources to diversify their experience with multiple databases. The fifth and final drug information activity included more complex questions than the first 4 activities, paired with a more complex patient scenario. Further, no guidance was given as to which type of resource the students should use to find the information. This fifth drug information activity was designed as a mini-capstone event and a way for students to demonstrate transfer of drug information skills to a novel and unguided patient case.

EVALUATION AND ASSESSMENT

Evaluation measurements of the assessment strategy were collected, including midterm examination averages, final examination averages, final grade distributions, and

student perceptions of the measure of knowledge for the midterm examination and final examination. All examination scores and questions are reviewed after the examinations were delivered to evaluate question performance. No questions were dropped from the examinations. Data collected from the semesters using the new assessment strategy (fall 2009 and spring 2010) were compared to the 2 previous offerings of the courses in which proctored examinations were used. The 4 versions of the midterm examinations and final examinations also were compared for both courses using ANOVA tests, with main effect of test.

Implementation of New Assessment Strategy and Evaluation

The new assessment strategy of using 4 parallel examinations for the midterm and final examinations was implemented in fall 2009. Enrollment in fall 2009 was 54 students in the undergraduate pharmacotherapy course and 47 in the graduate course. Enrollment in spring

2010 was 84 undergraduate students. Data from both semesters of the undergraduate course were combined, resulting in a total of 138 students.

Examination scores for the undergraduate students for fall 2009 and spring 2010 were combined and averaged. Scores on the 4 versions of the midterm examination were not significantly different in the undergraduate ($p = 0.353$) or the graduate course ($p = 0.214$). Average scores on the midterm examination ranged from 90.6% to 92.8% for undergraduate students and from 91.7% to 96.3% for graduate students.

The examination scores were combined and averaged for students in the fall 2009 and spring 2010 undergraduate pharmacotherapy course. Table 4 shows the 4 versions of the final examination for the 2 courses. In the undergraduate course, the final examination scores were significantly different ($p = 0.001$). Post hoc analysis revealed that scores on versions C and D of the examination were significantly different from scores on version A. Scores on version B were not significantly different from scores on any of the other 3 versions. Scores on versions C and D were not significantly different from each other. Scores on the 4 examinations for the graduate pharmacotherapy course did not differ significantly ($p = 0.321$). Average scores on the final examination ranged from 86.6% to 93.6% for undergraduate students and 90.4% to 95% for graduate students.

Overall final grade distributions for the semesters when the new assessment strategy was used were compared to previous semesters when proctored examinations were used. For undergraduate students in the fall 2009 and spring 2010 semesters, the percentage of students who earned an A grade was 79.6% and 53.6%, respectively (Table 5). In the 2 semesters before implementing the new assessment strategy, 49.2% of students in the undergraduate course earned an A. In fall 2009, 78.7% of students in the graduate pharmacotherapy course earned an

A compared to 79.8% of students in previous semester offerings.

Students rated the examinations' abilities to measure their knowledge for both the midterm (Table 6) and final examinations (Table 7) in the course evaluation at the end of each semester. For both courses, 46.2% of students in fall 2009 and 50.6% of students in spring 2010 rated the midterm examination's ability to measure their knowledge as more than satisfactory, compared to 31.3% of students historically. For both courses, 42.5% of students in fall 2009 and 46.1% of students in spring 2010 rated the final examination's ability to measure their knowledge as more than satisfactory, compared to 23.6% of students historically.

Drug Information Activity Quiz

All quiz scores for fall 2009 and spring 2010 for the undergraduate course were combined and averaged. The averages for the first 4 drug information quizzes were 89.0%, 79.9%, 99.1%, and 92.8% respectively. The average for the fifth and final drug information quiz was 93.76%. For the graduate course, the averages for the first 4 drug information quizzes were 95.3%, 96.2%, 100%, and 98.7%, and the average for the fifth quiz was 95.3%.

DISCUSSION

The use of online, case-based assessments for high-enrollment, online pharmacotherapy courses for graduate and undergraduate nursing students was successful in providing 4 parallel examinations that assessed students' case-based decision making skills, while maintaining academic integrity and minimizing the grading burden for instructors. Graduate and undergraduate students' performance on the 4 midterm and final examination was similar. The ease of administering and grading these examinations provided a manageable assessment method that

Table 4. Performance of Undergraduate and Graduate Nursing Students on Case-based Examinations Administered in an Online Pharmacotherapy Course

Examination Version	Undergraduate Pharmacotherapy Course (n=138)		Graduate Pharmacotherapy Course (n=47)	
	Midterm Examination Average, % ^a	Final Examination Average, % ^b	Midterm Examination Average, % ^c	Final Examination Average, % ^d
A	91.1	93.6	94.6	95.0
B	90.6	91.2	91.7	92.1
C	92.8	86.6	96.3	93.6
D	92.0	87.4	92.5	90.4

^a $p = 0.35$

^b $p = 0.001$

^c $p = 0.21$

^d $p = 0.32$

Table 5. Final Grade Distributions Before and After Parallel Case-Based Examinations in an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

Grade	Phar 3800			Phar 5800	
	Spring 2010, No. (%)	Fall 2009, No. (%)	Historical, No. (%) ^a	Fall 2009, No. (%)	Historical, No. (%) ^b
A	45 (53.6)	43 (79.6)	64 (49.2)	37 (78.7)	67 (79.8)
B	32 (38.1)	11 (20.4)	49 (37.7)	10 (21.3)	14 (16.7)
C	7 (8.3)	0 (0)	13 (10.0)	0 (0)	3 (3.6)
F	0 (0)	0 (0)	4 (3.1)	0 (0)	0 (0)

^a Includes data from spring 2009 and fall 2008.

^b Includes data from fall 2008 and fall 2007.

we continue to use in these courses. Minimal to no technical issues were reported during the delivery of the examinations.

While scores on the final examinations for the undergraduate course detected a difference between versions, scores on the identical final examinations for the graduate course did not differ significantly. Averages for the examinations were largely in the A grade range; however, this aligns with the redesign of the courses. One goal of reducing the amount of content and focusing on a smaller number of topics was to allow students to master the material; thus, the scores may be a reflection of this mastery. A larger percentage of students felt the online versions of the midterm and final examinations were better able to measure their knowledge compared to the previous face-to-face proctored examinations. Although there is a body of evidence suggesting that student perceptions of efficacy may not be indicative of increased learning outcomes,⁶ student satisfaction related to the course design and activities is relevant to student learning and has been found to be an important component of motivation.⁷

The act of completing the case-based assessments and learning activity may have furthered student learning and provided them with additional practice with clinical decision making. The idea that students often learn from an examination, especially from mistakes made on an examination, is not new; as Rash states “a primary goal of

assessment is to enhance learning.”^{8(p90)} Further, in their recent study evaluating the role of information retrieval in learning, Karpicke and Blunt argue that recalling information to answer an examination question requires a number of complex steps, including reconstructing content in a way that is relevant to the question at hand, and “thus mechanisms involved in retrieving knowledge play a role in producing learning.”^{9(p774)} While the act of retrieval was not evaluated in this study, further investigation on the influence of using case-based assessments as an additional learning strategy is warranted.

Using this assessment strategy of parallel case-based examinations delivered online has limitations. The creation of multiple examinations is time consuming for faculty members.^{10,11} The time to create the first case-based 20-item multiple-choice examination was approximately 20 hours, with subsequent versions of the examination taking approximately 10 hours or less. The examinations also must be comparable in difficulty and content. This study showed that the examinations were equally difficult, and this was accomplished using a systematic approach to ensure parallel concepts were covered in each version of the examinations. Using a chart or keeping a tabulation of the concepts that have been covered and repurposing examination questions by applying them to new patient cases are suggestions that may aid instructors in creating subsequent versions and revisions of an examination.

Table 6. Student Perception of Midterm Examination Ability to Measure Knowledge in an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

	Spring 2010, No. (%)	Fall 2009, No. (%)	Historical, No. (%) ^a
More than satisfactory	45 (50.6)	49 (46.2)	57 (31.3)
Satisfactory	38 (42.7)	38 (35.8)	79 (43.4)
Less than satisfactory	6 (6.7)	19 (17.9)	46 (25.3)

^a Includes data from spring 2009 and fall 2008.

Table 7. Student Perception of Final Examination Ability to Measure Knowledge in an Online Pharmacotherapy Course for Undergraduate and Graduate Nursing Students

	Spring 2010, No. (%)	Fall 2009, No. (%)	Historical, No. (%) ^a
More than satisfactory	41 (46.1)	45 (42.5)	43 (23.6)
Satisfactory	38 (42.7)	46 (43.4)	77 (42.3)
Less than satisfactory	10 (11.2)	15 (14.2)	62 (34.1)

^a Includes data from spring 2009 and fall 2008.

The case-based reasoning literature states that failure and reflection are essential components to educational design; however, neither was incorporated in this study, which primarily focused on the ability to create parallel, case-based examinations, administered online in a way which maintained academic integrity. Incorporating specific opportunities for students to fail in a low- to no-stakes learning environment and adding a reflection component will be the next steps in the continuous quality improvement of this course.

While this particular course was delivered to students in professional nursing programs, the concept can be applied to other high-enrollment courses in other professional healthcare programs, included pharmacy. As the number of pharmacy programs grow and enrollment increases, online delivery of courses may play a larger role in the curricula.

SUMMARY

Using an online, case-based assessment strategy proved to be an effective and feasible method for evaluating the clinical application knowledge of undergraduate and graduate nursing students in a high-enrollment online pharmacotherapy course. The teaching strategy satisfied both the case-based educational needs of the health professional students and incurred a manageable workload for the instructional team.

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REFERENCES

1. Barab SA, Dodge T. Strategies for designing embodied curriculum. In: Spector JM, Merrill MD, van Merriënboer J, Driscoll MP, eds. *Handbook of Research on Educational Communications and Technology*. 3rd ed. Cambridge, UK: Cambridge University Press;2008:97-110.
2. Bransford JD, Brown AL, Cocking RR, eds. *How People Learn: Brain, Mind, Experience, and School*. Expanded Ed. Washington: National Academy Press; 2000.
3. Kolodner JL, Guzdial M. Theory and practice of case-based learning aids. In Jonassen DH, Land SM, eds. *Theoretical Foundations of Learning Environments*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc;2000:215-242.
4. Job-Sluder K, Barab S. Shared 'we' and shared 'they' indicators of group identity in online teacher professional development. In: Barab SA, Kling R, Gray JH, eds. *Designing for Virtual Communities in the Service of Learning*. Cambridge, UK: Cambridge University Press;2004:377-403.
5. Gronlund NE, Linn RL. *Constructing Objective Test Items: Multiple-choice Forms. Measurement and Evaluation in Teaching*. 6th ed. New York: MacMillan;1990:166-191.
6. Clark RE. Antagonism between and enjoyment in ATI studies. *Educ Psychol*. 1982;17(2):92-101.
7. Pittenger AL, Doering AH. Influence of motivational design on completion rates in online self-study pharmacy-content courses. *Dist Educ*. 2010;31(3):275-293.
8. Rash AM. An alternative method of assessment: using student-created problems. *Primus*. 1997;7(1):89-95.
9. Karpick JD, Blunt JR. Retrieval practice produces more learning than elaborative studying with concept mapping. *Science*. 2011; 331(6018):772-775.
10. Nicol D. E-assessment by design: using multiple-choice tests to good effect. *J Furth High Educ*. 2007;31(1):53-64.
11. Arthur N. Using student-generated assessment items to enhance teamwork, feedback and the learning process. *Synergy*. 2006;24:21-23.