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REVIEW

Educational Games as a Teaching Tool in Pharmacy Curriculum

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The shift in the pharmacist's role from simply dispensing medications to effective delivery of pharmaceutical care interventions and drug therapy management has influenced pharmacy education.[1-3] The educational focus has shifted from basic sciences to clinical and integrated courses that require incorporating active-learning strategies to provide pharmacy graduates with higher levels of competencies and specialized skills. As opposed to passive didactic lectures, active-learning strategies address the educational content in an interactive learning environment to develop interpersonal, communication, and problem-solving skills needed by pharmacists to function effectively in their new roles.[4-6] One such strategy is using educational games. The aim of this paper is to review educational games adopted in different pharmacy schools and to aid educators in replicating the successfully implemented games and overcoming deficiencies in educational games. This review also highlights the main pitfalls within this research area.

Keywords: Educational games, pharmacy education, students' feedback, pharmacy students, active learning

INTRODUCTION

Games designed for serious purposes rather than just entertainment are gaining worldwide attention as they allow players to learn new skills and knowledge, stimulate physical activities, or enhance social-emotional development.[7-9] These games are widely applied within the educational field to facilitate students' learning through the integration of information in a competitive active environment.[10,11] An educational game is defined as an instructional method that requires the learner to participate in a competitive activity with preset rules.[12] It can support higher-level discussions that assist in enhancing students' communication, social collaboration, and critical-thinking skills, all of which are abilities essential to the pharmacist.[13,14] Further, educational games allow educators to create real-life scenarios within safe environment without real-life consequences.[15] Despite of the advantages of games in the health care field, the evidence of their pedagogical effectiveness is still in question.[16] Also, potential difficulties arise with the strategy as some students may find the competition among peers threatening or anxiety-causing.[17]

Even though a large number of studies have investigated using different active-learning approaches such as team-based learning,[18-23] case-based learning,[24-27] problem-based learning,[28-31] and simulations in pharmacy schools,[32-35] fewer studies have examined the usefulness of games in that context.[36-48] Additionally, there is no review to date that summarizes and validates the positive outcomes associated with educational games used in pharmacy schools.

We conducted a comprehensive electronic search to uncover all research articles relating to this topic in peer-reviewed journals. Databases, search engines, and specific academic journals were systematically searched up until January 2014. The following combinations of search terms were used: "educational games and pharmacist," "educational games and pharmacy," "games in pharmacy education," and "serious games in pharmacy education." Titles and abstracts resulting from the initial online searches were screened for relevance and eligibility for full-text retrieval. Additional articles were searched through citation by checking the reference sections of the sourced articles. Eligible articles were original, experimental full-text research articles published in English in which the intervention of interest was described as an educational game by the study author and in which pharmacy students were study participants. We excluded poster presentations and studies in which educational games occurred outside the discipline of pharmacy. Also excluded were role-plays not called games by the study author(s), and did not include a fun/excitement component (dice, game piece, game board, playing cards) or a specific gaming format (competitive activity with preset rules).

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FINDINGS

Title and abstract screening identified 17 potentially eligible articles. After complete text readings of the articles, 4 were excluded because they did not meet the criteria. Two articles were excluded as the impact of the games on student performance was not yet investigated because the games were still under development.[49,50] One study presented 4 medication-related educational board games but the study sample were community pharmacy patrons not pharmacy students.[51] Another was excluded because it was a descriptive report about the adaptation of 3 popular television game shows to pharmacy classes.[52] The remaining 13 papers were included regardless of their quality.

To facilitate comparisons, the following data were extracted and are presented in Tables 1 and 2: (1) types of game platforms; (2) number of students participating; (3) year of the students in professional pharmacy school; (4) courses in which games were taught; (5) awards, if any; (6) presence of facilitators/moderators; and (7) evaluation tool used.

Educational games are considered experiential learning methods that may contribute positively to students learning.[8] Research in this area explores the impact of these games on pharmacy students' satisfaction, knowledge, attitude change, and participation.[36,38-42,46] The 13 studies that met the inclusion criteria were published between 1995 and 2013 from pharmacy schools in the United States. Fewer studies on games in pharmacy education than those in other health related disciplines, such as medical and nursing fields, are available.[8,11,16,53] Depending on class size and subject matter, different game formats were reported. Patel and Barclay et al implemented diverse educational games to reinforce students' knowledge in pharmacotherapeutics, and most participating students reported the games contributed positively to their learning.[36,37] To develop empathy among pharmacists, several research groups implemented experiential

Table 1. Year of Candidature, Course, Study Sample, and Evaluation Criteria of Studies Where Educational Game Interventions were Implemented

Year of Candidature/ Course	Study Sample	Evaluation Criteria	Ref.
PY3/Principles of Human Disorders Pharmacotherapeutics Clinical Case Studies I and II	128	Postgame questionnaire (15 items including open ended questions)	36
Students enrolled in advanced pharmacy practice experience (APPE)	45	Preassessment and postassessment test (90 questions)	37
PY3/Professional Communication	48 15 control	Postgame questionnaire (23 MCQ + 6 open-ended questions)	38
PY1/Professional Communication	102	Pregame and postgame questionnaire (9 semantic questions with 6-point scale + 4 questions with 6-point Likert scale)	39
PY1/Pharmacy Practice Skills Lab	624	Pregame and postgame questionnaire (12 statements with 5-point Likert scale + free-text answers)	40
PY1-PY4/Geriatrics Electives	47	Guided open-ended reflection questions	41
PY3/Early Pharmacy Practice Experience (EPPE)	Not stated	Postgame survey (5 point Likert scale + open- ended questions)	42
PY3/Advanced Elective Psychiatric	160	Questionnaire + open-ended question	43
Year not stated/Gastrointestinal Integrated Sequence	82 (2008) 90 (2009)		44
PY1/Metabolism of Carbohydrates, Lipids, and Amino Acids	92	Survey instrument (10 items + written students comments)	45
PY2/Medication History Interviews at Ambulatory Clinic Sites (Preparation For IPPE)	200	Posttest (MCQ)	46
PY1/Introduction to Clinical Pharmacy Skills	130 (Fall Semester) 116 (Spring Semester)	Survey instrument (8 statements with 5-point Likert scale + additional comment if desired)	47
PY2/ Foundations in Pharmacokinetics Course and Applied Pharmacokinetics Course	132	Pretest and posttest (30 MCQ)	48

PY1=first professional year; PY2=second professional year; PY3=third professional year; PY4=fourth professional year; MCQ=multiple-choice questions

Table 2. Description of Educational Games Presented in Different Pharmacy Schools

Game Name and Description	Availability of Prizes/ Rewards	Facilitators/ Moderator	Ref No.
Who Wants To Be A Med Chem Millionaire? Six teams (each of 6 members) sit in front of the classroom while nonplaying students remain in the classroom as "studio audience." Game questions are projected on screens and teams ring a bell to answer a question. Play time is 45 minutes. The team with the most *Med Chem Moolah* (play money) at the end of their session wins.	Money donated to charity named by winning team	Faculty members (each for one hour play)	42
Who Wants To be a Millionaire? Five multiple-choice questions are presented to students using PowerPoint. The first student to raise his/her hand is selected by the instructor to answer the question. Students can be assisted by a friend in the room, or by audience help via a poll. Game time is approximately 5 minutes and is followed by a lecture.	Candy prizes		43
Jeopardy. The class is randomly assigned to 16 teams, each of approximately 10 students. The teams sit in assigned areas in the classroom. A student from the audience selects a question to display on a PowerPoint projection overhead. Any group can participate by raising hand to answer the question. Correct answers are awarded the appropriate points, and that team selects the next question. If a group answers incorrectly, a second team attempts to answer and earn the points. Game time is approximately 30 minutes, followed by a 45-minute lecture.	Extra credit point to group with highest score	Two moderators	43
Survivor. Teams of 20 students are asked 3 major questions. They take 5 minutes to discuss the question within their groups. One member of each team writes the answers on a whiteboard at the front of the lecture hall. The team with the largest number of correct answers proceeds to the next question. This cycle is repeated for all 3 questions. Game time is 1.5 hours.		One moderator	43
Crossword puzzle. The whole class participates in solving a 5-minute crossword puzzle containing information presented in the lecture.			44
Race to Glucose. Students in groups of 5 or 6 roll a die and move game pieces along the gluconeogenesis pathway while addressing questions and changes in physiological conditions. The team who finishes the pathway first wins. Game time is approximately 2 hours on 2 consecutive days.			45

(*Continued*)

Table 2. (*Continued*)

Game Name and Description	Availability of Prizes/ Rewards	Facilitators/ Moderator	Ref No.
Medication Mysteries Infinite Case Tool (MMICT). During a 2-hour laboratory session, groups of 3 students are provided with the MMICT packet containing a game board, decks of drug, confusion, and personality cards, a 6-sided die, instruction sheet, patient demographic sheets, and an evaluation rubric. Each student assumes a role: patient, pharmacist, or evaluator.		At least one facilitator	46
Bingo Game. The game is composed of a 5x5 grid with total of 25 squares, each containing an activity to encourage students to review course material (online self- quizzes), to motivate students to perform better on graded activities (examinations and competencies), to appeal to students with different learning styles (posters, computer animations, videos, crossword puzzles), and to encourage close attention to required material (identify errors in textbook or class). Students who achieve bingo (5 squares in a row vertically, horizontally, or corner-to-corner) earn a 5-point (5%) bonus added to the final course grade.	5 percent added to final course grade		47
PK Poker. The class is divided into 13 groups of approximately 10 students. Each group start with a $500 bankroll and place a bet on their ability to answer a question correctly. Students have 2 minutes to respond to each question. Game time is 50 minutes for 2 class periods.	Bonus points added to the total points of the course.	Two instructors	48
Pharmacy Scene Investigation (PSI). The class is divided into 6 groups of approximately 22 students with 2 members acting as lead detectives. The game presents an unsolved death scenario about an individual found dead with initial indications of suicide and multiple potential murderer suspects. The game is presented divided into one 50-minute class to play and one 50-minute class to debrief.		One faculty member	
Clue Game (CG). Game is based on a murder mystery. Each student in a 5-member group researches 4 different drugs from the Top 300 drugs, then teaches them to other group members. Students received clues to determine the murderer (eg, physician who prescribed a medication with severe adverse effects), weapon used, and location. If the student answers correctly, the group successfully completes the game. If the student does not, the team is disqualified. Game time is one 50-minute class period to play and one 50-minute class to debrief.		Three instructors and 2 faculty members	

role play games related to older adults. The authors considered them educational games based on the presence of fun components and preset rules (students' progress was based on correct answers or appropriate performance). In addition, they were competitive in nature as they encompassed winning criteria and prizes.[38-41] Other researchers used *The Geriatric Medication Game* to allow students to temporarily experience the changes in physical abilities older adults encounter.[38-40] After participating in this game, some students showed increased understanding of geriatric needs. Likewise, Kennedy et al reported that *The Age Game,* a similar interactive simulation board game, enhanced student empathy toward older adults.[41] Some researchers adapted games from popular TV shows, such as Roche, who employed *Who Wants to Be a Med Chem Millionaire* in an Early Pharmacy Practice Experience course and Grady et al, who adopted *Who Wants to Be a Millionaire*, *Jeopardy*, and *Survivor* to promote learning in an Advanced Psychiatric Pharmacy elective course.[42,43] Students positively perceived the *Crossword Puzzles* used by Shah et al during didactic lectures to restart the students' attention clock.[44,54] Also, the *Race to Glucose* board game developed by Rose was helpful for learning some aspects of the metabolic pathways.[45] Sando et al reported the usefulness of *Medication Mysteries Infinite Case Tool (MMICT)* in preparing students for conduct medication history interviews.[46] To increase students' interaction with course material, Tietze developed an extra-credit bingo game with different educational activities that helped students review course material.[47] Further, Persky et al presented 3 different games, *PK Poker*, *Pharmacy Scene Investigation (PSI)*, and *Clue Game* to promote students' learning in pharmacokinetics.[48] Students found these games to be valuable as supplementary learning tools rather than replacements for traditional lectures.

In the 13 studies, games assisted in teaching students course material throughout the pharmacy curriculum starting from the first year of the pharmacy degree and continue until the fourth year and in pharmacy practice experiences.[37,42,46] Basically, the use of games in pharmacy schools was not intended to present new content, but to review or reinforce existing knowledge.[36,44,48]

In 10 studies, moderators or other faculty members assisted in game setup and introduction, guiding students through different stations and helping in the debriefing session. Sando et al presented the feedback of faculty members involved in facilitating the *MMICT* as well as preceptors' satisfaction with students' performance during the ambulatory clinic introductory pharmacy practice experiences (IPPE).[46] Faculty members stated that the *MMICT* game was easily facilitated and students actively participated.[46]

Rewards in Educational Games

The use of rewards in educational settings to improve student motivation is controversial.[55] Some argue that rewards are detrimental because student motivation is undermined if rewards are removed.[56,57] Other researchers claim that rewards contribute to increasing motivation and performance.[55,58] Five studies involved rewards to motivate students.[36,40,42,43,47] Two studies reported rewarding students by adding extra marks to their grades, while one study included candy prizes for winning teams.[43,47] Instead of giving the winning team a reward, Roche et al asked the winning team to select a health-related charity to which a faculty member would donate if that team won. Students involved in that study claimed to be highly motivated knowing that money would be donated to a good cause.

Debriefing or Reflecting Sessions

Debriefing is a critical component in the educational process. Debriefing includes reflecting and assimilating activities into a learner's cognition to foster long-lasting learning.[59] To enable students to develop strategies for enhancing future performance, debriefing involves a 2-way communication between student and teacher.[60,61] In *PSI* and *Clue Game*, a 50-minute debrief session was presented in the class period following the game.[43] Some authors reported the presence of discussion session after the game to reinforce the information presented during game play. The games presented by Patel were 1 hour in length followed by and additional hour for discussion and questions.[36] Also, in the *Geriatric Medication Games*, the third phase included a facilitator-led discussion or reflection phase so players could discuss their experiences and emotions during the game.[38-40] Being presented directly after the game, phase 3 reinforced the lessons acquired from the game and allowed the facilitator to correct any misperceptions or stereotyping toward the elderly.[38-40]

DISCUSSION

Advantages and Disadvantages of Educational Games

The main advantages of games include interactive participation of the students and their excitement while playing.[48] Oblinger described millennial students (born between 1980 and 1991) as participatory learners who prefer assembling information from a variety of sources.[62] Thus, games perfectly suit millennials because games generate enthusiasm and stimulation throughout the educational process, as noted in the positive feedback from students. Educational games also foster a less stressful environment for students—an advantage because anxiety often hinders full engagement in discussions.[36]

A noted strength of games is their ability to promote student-to-student interaction and peer learning.[45] For example, Persky et al assigned students with different grades and gender to groups to achieve balanced distribution and to promote interaction between individuals who might not usually associate in the class.[48] Further, some games, such as the *Geriatric Medication Game*, allowed students to apply what they learned in lectures to realistic situations.[38-40] In addition, preceptors or faculty members who assisted in games reported that games accomplished their goals based on the observed improvement in students' confidence and performance.[42]

The majority of studies reported students were highly satisfied with games and found them enjoyable, interactive and stimulating.[44] However, in some studies, students felt games weren't beneficial and did not improve their test scores.[48] Even though games are reported to be less stressful, some students may feel overwhelmed because they need to learn to play the game in addition to recalling the educational material.[36] Hence, games may be ineffective for learners who struggle to process information or who do not enjoy playing games.[36] In addition, students reported that the games were not helpful in learning certain topics or aspects such as reactions.[45] In an attempt to decrease students' anxiety and improve participation during the game, Persky et al devised a scoring scheme where the students didn't lose points for incorrect answers.[48] Other disadvantages were found in games where only small percentage of the class participated while the remaining students were the game's audience, thus failing to engage the entire class.[42] Also, the large number of students in some games decreased the game's speed, causing students frustration.[48] Moreover, it was hard to maintain control in classes with large number of students.[43]

Pharmacy educators are still reluctant to implement educational games as the design can pose challenges. The common shortcomings shared by different games include the time spent by students learning the game and the extensive time invested by faculty members in game development.[36,37,41,45,47]Once prepared, however, the game material can be reused with minimal time commitment.[45] The cost of purchasing the game supplies was one of the key hindrances reported in the geriatrics-related games.[39] Moderating and implementing some games also required assistance of other faculty members or facilitators, which increased their workload.[37]

Assessing the impact of educational games is crucial to identify their strengths and weaknesses and perform the necessary revisions and modifications. In all the reported studies, the authors used questionnaires (student surveys) to determine student interest level and satisfaction with the game experience. Complementary to the questionnaire, open-ended questions or free-text responses were included in 10 articles to determine students' perceived value of the games.[36,40-42] Shah et al relied on students' posttest scores for objective measurement of the games success.[44] The more effective approach for assessing game impact was to compare students' posttest scores, after games introduction, to their pretest scores.[37,38,45,46] In most of the studies, the pretest and posttest were conducted before and after the teaching session so the impact of the game intervention on information retention was not investigated. To minimize response-shift bias that might occur using traditional pretest/posttest survey design, Sando et al utilized a retrospective pretest-posttest design.[46] Persky et al compared the postgame examination score to the examination scores of students from the previous year.[48] While each year contained 2 different populations of students, the author claimed that the similar admissions criteria and grades for students supported the assumption that the student populations were similar. Oliver et al's study did compare responses of students who participated in the game to those of a student control group who attended class without games.[38]

Limitations of the Included Studies

The reviewed studies differed in how they reported methodological and study design limitations. Nearly half of the studies did not mention limitations while the rest (n=7) reported some limitations including too small a sample size to ensure results validity,[41,43] a small number of received responses to questionnaires,[43,46] the absence of control group[42] or pretest performance,[41] and a lack of a definite magnitude between grades of Likert scale.[39] Chen et al reported students might have felt obligated to respond favorably to the questionnaire.[40] In addition, Kennedy et al used a postgame survey that collected student opinion but did not evaluate whether a change in behavior occurred.[41]

Designing an Effective Educational Game

Effective games should share certain criteria to guarantee successful impact on student learning. Primarily, their objectives and expected educational outcomes should be clearly defined.[36] Balance between the entertainment and educational components needs to be considered.[63] The more enjoyable an educational game is, the more likely students will persist in playing it. Yet, the instructor must ensure that educational information is not lost in the excitement and competition of the game. Further, the difficulty level of the game should be moderate as difficult games discourage students from participating.[44] Another important consideration in game design

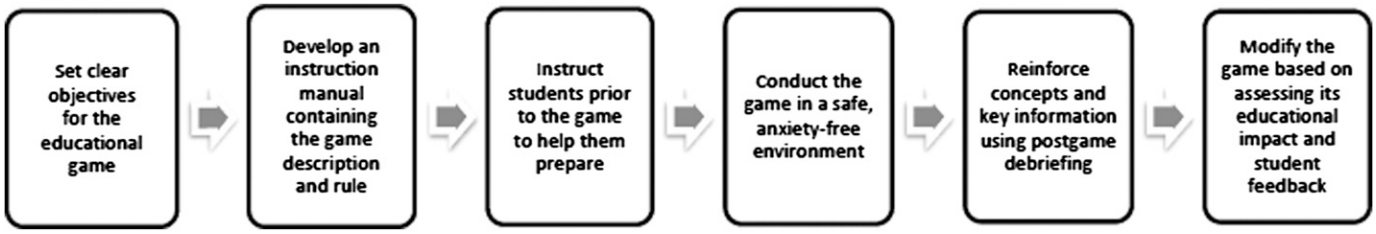

Figure 1. Descriptive steps for proper educational game design

is a group size adequate to ensure active participation by all students. The competitive element of the game should be sensible to encourage motivation without promoting conflict between students or discourage individuals with insufficient knowledge or low self-esteem.[64] Game rewards should be matched with the difficulty of learning tasks. Clear instructions should be developed and provided to students prior to starting the game to help them prepare.[36,42] Games should not serve as the only means of relaying information to students but should reinforce and assess students' understanding of certain information. To maintain a high level of engagement, timely and appropriate feedback pertinent to progress and performance level should be given to students.[42,45] In addition, feedback is needed to allow students to determine the gap between current knowledge and that required for completion of the game's task.[65] Students debriefing is essential to reinforce concepts and clarify key information conveyed in the game.[59] Games should be continuously updated and modified based on student feedback.[45] Considering the advancement of the computer gaming technology and the passion among millennial students for it, there is a need for designing computer-based educational games that cater to pharmacy students. Descriptive steps for designing proper educational games are illustrated in Figure 1.

Implications for Future Evaluations

This review revealed the absence of randomized controlled studies with solid evidence of the educational benefits of games in pharmacy education. Yet, the positive feedback noted in the literature, as expressed by pharmacy students and authors, indicate that games may be a promising learning modality once properly designed.[41-46] In order to obtain unequivocal proof for game benefits, appropriate educational research should be conducted to validate games as effective teaching tools. Dissemination of educational pharmacy games to a broader population of pharmacy students in countries other than the United States is important for demographic evaluation of their impact on students. Comparing randomized studies on lecture formats or other teaching techniques to those on games should be conducted to evaluate games' effect on learning relative to other teaching modalities. Although educational games are effective in engaging students, determining the impact of games on improving examination scores requires proper assessment instead of focus on student perception of gaming activity. This requires the establishment of criteria for competency-based performance assessment. Future studies should consider whether associations exist between educational games and students' ability to retain information.

Limitations of the Review

Even though rigorous attempts were made to ensure this review covered all articles on educational games in the pharmacy curriculum to date, some papers may not have been identified. Nevertheless, this limitation does not influence the reporting of popular game formats, advantages and disadvantages of games, student feedback on games, and the main shortcomings within this research area.

CONCLUSION

Adequate evidence that educational games foster learning in pharmacy schools is lacking. What does exist is the potential of a positive impact of properly designed educational games on learning. Educational games can help complement and reinforce taught material by promoting students' participation and engagement in an interactive, enjoyable, and motivational learning environment. The major barriers to the wide spread use of educational games are mainly time consumed, cost, and the absence of validated, well designed games. Collaboration between educators and designers is crucial to ensure proper design of educational games that balance educational and entertainment components. Moreover, quality research using proper methodological design is strongly recommended in this area to gain firm conclusions regarding the impact of educational games on pharmacy student performance.

REFERENCES

1. Kiersma ME, Plake KS, Newton GD, Mason HL. Factors affecting pre pharmacy students' perceptions of the professional role of pharmacists. *Am J Pharm Educ.* 2010;74(9):Article 161.

2. Haines SL, Amburgh JAV. A vidcasting project to promote the pharmacist's role in public health. *Am J Pharm Educ*. 2010;74(6): Article 97.
3. Boyle M, Myford C. Pharmacists' expectations for entry-level practitioner competency. *Am J Pharm Educ*. 2013;77(1):Article 5.
4. Stewart DW, Brown SD, Clavier CW, Wyatt J. Active-learning processes used in US pharmacy education. *Am J Pharm Educ*. 2011;75(4):Article 68.
5. Gleason BL, Peeters MJ, Resman-Targoff BH, et al. An active-learning strategies primer for achieving ability-based educational outcomes. *Am J Pharm Educ*. 2011;75(9):Article 186.
6. Donohoe KL, Mawyer TM, Stevens JT, Morgan LA, Harpe SE. An active-learning laboratory on immunizations. *Am J Pharm Educ*. 2012;76(10):Article198.
7. Hromek R. Promoting social and emotional learning with games "it's fun and we learn things". *Simulat Gaming*. 2009;40(5):626-644.
8. Graafland M, Schraagen JM, Schijven MP. Systematic review of serious games for medical education and surgical skills training. *Br J Surg.* 2012;99(10):1322-1330.
9. Johnston B, Boyle L, MacArthur E, Manion BF. The role of technology and digital gaming in nurse education. *Nurs Stand* 2013; 27(28): 35-38.
10. Blakely G1, Skirton H, Cooper S, Allum P, Nelmes P. Use of educational games in the health professions: a mixed-methods study of educators' perspectives in the UK. *Nurs Health Sci.* 2010;12 (1):27-32.
11. Akl EA, Pretorius RW, Sackett K, et al. The effect of educational games on medical students' learning outcomes: a systematic review. *Med Teach*. 2010;32(1):16-27.
12. Fitzgerald K. Instructional methods: Selection, use, and evaluation. In: Bastable S ed. *Nurse as Educator: Principles of Teaching and Learning*. Sudbury, MA: Jones and Bartlett, 1997:261-86.
13. Guillén-Nieto V, Aleson-Carbonell M. Serious games and learning effectiveness: The case of it's a deal! *Comput Educ.* 2012;58 (1) 435-448.
14. Michael C. Students' experiences of active engagement through cooperative learning activities in lectures. Active Learning in Higher Education. 2011;12(1): 23-33.
15. Aebersold M, Tschannen D, Stephens M, Anderson P, Lei X. Second Life: a new strategy in educating nursing students. *Clin Simu Nurs.* 2012;8(9):469-475.
16. Blakely G, Skirton H, Cooper S, Allum P, Nelmes P. Educational gaming in the health sciences: systematic review. *J Adv Nurs*. 2009;65(2):259-269.
17. Henderson D. Games: making learning fun. In *Annual Review of Nursing Education,* v.3. 2005; 165-183.
18. Conway SE, Johnson JL, Ripley TL. Integration of team-based learning strategies into a cardiovascular module. *Am J Pharm Educ*.2010;74(2):Article 35.
19. Addo-Atuah J. Performance and perceptions of pharmacy students using team-based learning (tbl) within a global health course. *Innov Pharm*. 2011;2(2):1-15.
20. Beatty SJ, Kelley KA, Metzger AH, Bellebaum KL, McAuley JW. Team-based learning in therapeutics workshop sessions. *Am J Pharm Educ.* 2009;73(6):Article 100.
21. Pogge E. A team-based learning course on nutrition and lifestyle modification. *Am J Pharm Educ*. 2013;77(5):Article 103.
22. Allen RE, Copeland J, Franks AS, et al. Team-based learning in us colleges and schools of pharmacy. *Am J Pharm Educ*. 2013;77(6): Article 115.
23. Ofstad W, Brunner LJ. Team-based learning in pharmacy education. *Am J Pharm Educ*. 2013;77(4):Article 70.
24. Reddy IK. Implementation of a pharmaceutics course in a large class through active learning using quick-thinks and case-based learning. *Am J Pharm Educ*. 2000;64(4):348-355.
25. Cisnerosa RM, Salisbury-Glennonb JD, Anderson-Harper AH. Status of problem-based learning research in pharmacy education: a call for future research. *Am J Pharm Educ.* 2002;66(Spring):19-26.
26. Brown SD, Pond BB, Creekmore KA. A case-based toxicology elective course to enhance student learning in pharmacotherapy. *Am J Pharm Educ*. 2011;75(6):Article 118.
27. Ha H, Lopez T. Developing health literacy knowledge and skills through case-based learning. *Am J Pharm Educ*. 2014;78(1):Article 17.
28. Borrego ME, Rhyne R, Hansbarger LC, et al. Pharmacy student participation in rural interdisciplinary education using problem based learning (pbl) case tutorials. *Am J Pharm Educ.* 2000;64(4):355-363.
29. Pungente MD, Wasan KM, Moffett C. Using learning styles to evaluate first-year pharmacy students' preferences toward different activities associated with the problem-based learning approach. *Am J Pharm Educ.* 2003;66(2):119-124.
30. Novak S, Shah S, Wilson JP, Lawson KA, Salzman RD. Pharmacy students' learning styles before and after a problem-based learning experience. *Am J Pharm Educ*.2006;70(4):Article 74.
31. Ellis RA, Goodyear P, Brillant M, Prosser M. Student experiences of problem-based learning in pharmacy: conceptions of learning, approaches to learning and the integration of face-to-face and on-line activities. *Adv Health Sci Educ Theory Pract*. 2008;13 (5):675-692.
32. Seybert AL. Patient simulation in pharmacy education. *Am J Pharm Educ*. 2011;75(9):Article 187.
33. Lin K, Travlos DV, Wadelin JW, Vlasses PH. Simulation and introductory pharmacy practice experiences. *Am J Pharm Educ*. 2011;75(10):Article 209.
34. Benedict N, Schonder K, McGee J. Promotion of self-directed learning using virtual patient cases. *Am J Pharm Educ*.2013;77(7): Article 151.
35. Mieure KD, Vincent WR, Cox MR, Jones MD. A high-fidelity simulation mannequin to introduce pharmacy students to advanced cardiovascular life support. *Am J Pharm Educ*.2010;74(2):Article 22.
36. Patel J. Using game format in small group classes for pharmacotherapeutics case studies. *Am J Pharm Educ.* 2008;72(1): Article 21.
37. Barclay SM, Jeffres MN, Bhakta R. Educational card games to teach pharmacotherapeutics in an advanced pharmacy practice experience. *Am J Pharm Educ.* 2011;75(2):Article 33.
38. Oliver CH, Hurd PD, Beavers M, Gibbs E, Goeckner B, Miller K. Experiential learning about the elderly: the geriatric medication game. *Am J Pharm Educ.* 1995;59(2):155-158.
39. Evans S, Lombardo M, Belgeri M, and Fontane P. The geriatric medication game in pharmacy education. *Am J Pharm Educ.* 2005;69 (3):Article 46.
40. Chen AMH, Plake KS, Yehle KS, Kiersma ME. Impact of the geriatric medication game on pharmacy students 'attitudes toward older adults. *Am J Pharm Educ*. 2011;75(8):Article 158.
41. Kennedy DH, Fanning KD, Thornton PL. The Age Game: An interactive tool to supplement course material in a geriatrics elective. *Am J Pharm Educ*. 2004;68(5):Article 115.
42. Roche VF, Alsharif NZ, and Ogunbadeniyi AM. Reinforcing the relevance of chemistry to the practice of pharmacy through the who wants to be a med chem millionaire? learning game. *Am J Pharm Educ.* 2004;68(5):Article 116.

43. Grady SE, Vest KM, Todd TJ. Student attitudes toward the use of games to promote learning in the large classroom setting. *Curr Pharm Teach Learn.* 2013;5(4):263-268.
44. Shah S, Lynch LMJ, Macias-Moriarity LZ. Crossword puzzles as a tool to enhance learning about anti-ulcer agents. *Am J Pharm Educ.* 2010;74(7):Article 117.
45. Rose TM. A board game to assist pharmacy students in learning metabolic pathways. *Am J Pharm Educ.* 2011;75(9):Article 183.
46. Sando KR, Elliott J, Stanton ML, Doty R. An educational tool for teaching medication history taking to pharmacy students. *Am J Pharm Educ.* 2013;77(5):Article 105.
47. Tietze KJ. A bingo game motivates students to interact with course material. *Am J Pharm Educ.* 2007;71(4):Article 79.
48. Persky AM, Stegall-Zanation J, Dupuis RE. Students' perceptions of the incorporation of games into classroom instruction for basic and clinical pharmacokinetics. *Am J Pharm Educ.* 2007;71 (2):Article 21.
49. Yap KYL, Wong LL, Yap KZ, Chui WK, Yap JYG and Athreya US. Gamification of pharmacy practices: learning how to manage patients the fun way. *Technol enhanced Learn.* 2013.
50. Dudzinski M, Ishtiaq S, Gatsinzi F, et al. Evaluation of pharmacy students' perceptions regarding the use of games to support their learning. *High Educ. Acad.* 2013.
51. Burghardt KJ, Bowman MR, Hibino M, et al. Using educational games to promote the seeking of a pharmacist and to teach key medication use messages: results from an inner city health party. *Res Social Adm Pharm*. 2013;9(5):542-552.
52. Chavez B, Gilliam EH, Pathak R, Volino LR. Popular game shows as educational tools in the pharmacy classroom. *Curr Pharm Teach Learn*. 2012;4(2):146-149.
53. Royse MA, Newton SE. How gaming is used as an innovative strategy for nursing education. *Nurs Educ Presp*. 2007;28(5):263-267.
54. Middendorf J, Kalish A. The ''change-up'' in lectures. *Natl Teach Learn Forum*. 1996;5(2):1-7.
55. Cameron J, Pierce WD, Banko KM, Gear A. Achievement-based rewards and intrinsic motivation: a test of cognitive mediators. *J Educ Psychol.* 2005;97(4):641-655.
56. Deci EL, Koestner R, Ryan RM. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychol Bull.* 1999;125(6):627-668.
57. Deci EL, Koestner R, Ryan RM. Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research*. 2001;71(1):1-27.
58. Cameron J. Negative effects of reward on intrinsic motivation-A limited phenomenon: Comment on Deci, Koestner, and Ryan (2001). *Review of Educational Research*. 2001;71(1):29-42.
59. Fanning R., Gaba D. The role of debriefing in simulation based learning. *Simul Healthc*. 2007;2(1):115-125.
60. Cant RP, Cooper SJ. The benefits of debriefing as formative feedback in nurse education. *Aust J Adv Nurs*. 2002;29(1):5-13.
61. Shute V. Focus on formative feedback. Educational Testing Service, Princeton, New Jersey. Educational Testing Service. 2007.
62. Oblinger D, Oblinger J. Is it age or IT: first steps toward understanding the net generation In: *Educating the Net Generation*. Boulder, CO: Edu cause; 2005.
63. Marsh T, Nickole LZ, Klopfer E, Xuejin C, Osterweil S, Haas J. Fun and learning: Blending design and development dimensions in serious games through narrative and characters. In *Serious Games and Edutainment Applications*. Springer, 2011:273-287.
64. Sedano CI, Pawlowski J, Sutinen E, Vinni M, Laine TH. From Global Games to Re-contextualized Games: The Design Process of TekMyst. *Serious Games and Edutainment Applications*. Springer. 2011:Chapter 11.
65. Hattie J, Timperley H. The power of feedback. *Rev Educ Res.* 2007;77(1):81-112.