PLAYING WITH EVIDENCE-BASED LEARNING STRATEGIES: USE OF AN ONLINE GAME WITH THE TESTING AND SPACING EFFECT

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LEARNING OBJECTIVES

- Summarize game-based active-learning strategies in health professional education.
- Explain the evidence-based learning strategies of the spacing and testing effect.
- Describe the use of an online spaced education (SE) game to teach common medications (e.g. Top 200 medications) in pharmacy education.
- Develop a research plan to evaluate a game-based teaching strategy.
Poll

Who do we have in the audience?
- A. Medicine
- B. Pharmacy
- C. Nursing
- D. Public Health and Health Professions
- E. Veterinary Medicine
- F. Dental
What experience do you have using game-based strategies in your teaching?

A. I’m a pro – I’ve implemented several game-based teaching strategies.

B. I’m a semi-pro – I’ve tried at least one game-based strategy in my teaching.

C. I’m a novice – I’ve never implemented a game-based teaching strategy but I’m interested in trying it.

D. Games are no fun – I’ve never implemented a game-based teaching strategy and I have no interest in trying it.
Common belief that lectures or reading material have lowest retention methods
• Games are considered a “participatory” teaching method
• Learning Pyramid is commonly cited in support of active learning methods – Controversial!

• Learning and retention of knowledge is complex and multiple methods should often be used
  • Memory matters
  • Multimodal
  • Student engagement

http://acrlog.org/2014/01/13/tales-of-the-undead-learning-theories-the-learning-pyramid/comment-page-1/
DEFINING GAMIFICATION

- Also referred to as “serious games”
- Use of game principles for the purposes of learning, skill acquisition, and training.
- Voluntary attempt to overcome unnecessary obstacles
- Not just simulation

ESSENTIALS OF GAME-DESIGN

- Caillois Model
  - Competition or conflict
  - Chance or luck
  - Ilinx – physical experiences or performance
  - Mimicry

- Other game elements
  - Tactics and strategies
  - Media
  - Symbols and actions
  - Complexity and difficulty

Ellaway RH. Ellaway Advances in Simulation (2016) 1:28
CATEGORIES OF GAMES

- Simulations/Role-Play
- Virtual Environments
- Social and Cooperative Play
- Alternative Reality Games

# Gamification — Does It Work?

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of Studies Examined</th>
<th>Major Findings/Conclusions</th>
</tr>
</thead>
</table>
| Randel JM, et al. Simulation and Gaming. 1992;23(3):261-276 | 67                         | • Games rated as **more interesting** vs. conventional instruction  
• 32% of studies favored games |
| Wolfe J. Simulation and Gaming. 1997;28(4):360-376 | 7                          | • Game-based approach produced **significant knowledge increases** vs. case-based teaching |
| Hays RT. Naval Air Warfare Center Training Systems Division. 2005 (No 2005 – 004) | 105                        | • Design to meet specific instructional objectives  
• Include debriefing and feedback  
• Instructional support to increase effectiveness |
| Vogel JJ, et al. Journal of Educational Computing and Research. 2006;34(3):229-243 | 32                         | • **Higher cognitive gains** using simulation or games vs. traditional teaching methods (simulations had stronger results) |

# Gamification — Does it Work?

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<tbody>
<tr>
<td>Ke F. Effective electronic gaming in higher education. 2009; Vol 1: 1-32.</td>
<td>65</td>
<td>• <strong>Effects of learning</strong> with games was positive in 52% of studies examined</td>
</tr>
</tbody>
</table>
| Sitzmann T. Personnel Psychology. 2011; 64(2):489-528. | 65                        | • **Greater confidence** with games  
• Declarative, procedural knowledge and retention higher with simulation  
• **Simulation performed better when embedded** with instruction vs. stand-alone. |

GAMIFICATION -- FOCUS ON MED ED

- Systematic review of educational games in medical education
- RCTs, controlled clinical trials and interrupted time series
- Population: Medical students
- 1019 citations screened → Only 5 papers were eligible (one with dental students)
- Low to moderate methodological quality
- 3 of 5 studies suggest a positive effect on knowledge
- Highlights need for additional well-designed studies

**TRAITS OF WELL-CONSTRUCTED GAMES**

- Learning goals provide purpose to the game and focus the learner’s attention
  - Learning goals may change through different levels of the game
- Rules provide limits to the learner’s path
- Feedback informs learners how they are progressing towards a goal
- Learner accepts the game elements and is free to enter or leave the game as they wish
- Game must flow – AKA be sufficiently challenging

Cain J, Pascik P. Am J Pharm Ed. 2015;79(4): Article 47
ACTIVITY #1

- Share a game-based teaching strategy you have used in your course and how you evaluated its effectiveness OR

- Think about a game-based teaching strategy you would like to try
  - Quizzing platforms – Kahoot, Socrative, etc.
  - Escape room
  - Board games
  - TV game formats – Family Feud, Jeopardy, etc.

- What learning objective(s) do you want students to achieve?
KIRKPATRICK MODEL OF PROGRAM EVALUATION

Results
- Patient outcomes; Employment rates; Licensing exam pass rates; Residency matching, etc.

Behavior
- Simulation or workplace-based assessments; hand-washing; study habits, etc.

Learning
- Knowledge assessment; pre- and post-examination

Reaction
- Surveys or Focus groups
CASE STUDY

“This material is not sticking! How can I study more effectively?”
WHAT DO YOU TELL JOE?

A. Keep re-reading your lecture notes and assigned readings
B. Highlight key ideas from lecture notes and assigned readings
C. Summarize key points in the margins of your readings or lecture notes
D. Complete practice multiple-choice tests on the material
EVIDENCE-BASED LEARNING STRATEGIES

Spacing Effect (distributed practice)

Testing Effect (retrieval practice)

Interleaving

38 Surgical Residents to learn microsurgery (how to reattach tiny vessels)

Each lesson consisted of:
• Instruction
• Practice

Citation: Moulton CAE et al. Annals of Surgery. 2006(244):400-409
Pediatric and emergency med residents

1-hour teaching session on status epilepticus (SE) or myasthenia gravis (MG)

Immediately then every 2 weeks for 2 sessions

TESTING EFFECT

(a) Status epilepticus
(b) Myasthenia gravis
ACTIVITY #3

- Do you have experience implementing evidence-based learning strategies in your courses or in the clinical setting?
- What are some ways you think you could implement spacing, the testing effect, or interleaving?
- How would this relate to some of the game-based teaching strategies you are planning?
At Harvard Macy Institute, QStream® was used between Jan and May sessions for important course concepts.
THE TOP 200 DRUGS IN PHARMACY EDUCATION

- ACPE Standard 1.1 – Foundational knowledge of commonly used medications, formulations, and drug products
- Few published studies evaluating methods for teaching and assessing Top 200 drug knowledge
- Usually self-guided study as part of lab or recitation component
- Difficulty with long-term retention of drug information
<table>
<thead>
<tr>
<th>Citation</th>
<th>Intervention</th>
<th>Evaluation</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilson, J et al 2014 Curr Pharm Teach Learn</td>
<td>Top 200 drug info exercises in lab curriculum</td>
<td>Student perception (survey) Preceptor perception of preparedness (survey)</td>
<td>Students – 93% felt exercises were helpful Preceptors – 40% (35/88) felt students were better prepared vs. other institutions</td>
</tr>
<tr>
<td>O’Brocata 2013 Curr Pharm Teach Learn</td>
<td>Top 200 drugs course (P1) using active learning techniques</td>
<td>Student perception (survey) Course grades</td>
<td>Student perceptions overall positive Course grades were high (92% (n=66) were ≥80%)</td>
</tr>
<tr>
<td>Greene, et al. 2010 AJPE</td>
<td>Top 200 drugs course (P1) year</td>
<td>Correlation of pre-pharmacy work experience to course grades</td>
<td>Lowest grades correlated to little or no prior work experience ($\alpha = 0.01, r = 0.284, t = 5.23$)</td>
</tr>
<tr>
<td>Santee, J 2003 AJPE</td>
<td>Internet-based practice examination in P2 and P3 years</td>
<td>Correlation between course GPA and number of times required to pass practice exam and % correct</td>
<td>No difference in performance in those who took practice test vs. those who didn’t</td>
</tr>
</tbody>
</table>
NEW P1 LABORATORY COURSE

P3 lab and IPPE courses

Skill Development (Legacy Curriculum)

New 3-year laboratory sequence

Begin Fall 2015

P1 course coordinator

Foundational skills with ambulatory and community focus
Pre-Lab Activities
• Introduction to Blood Pressure Measurement and Vital signs (30 min)
• Complete virtual patient module (Cardiovascular Assessment)

Start of Lab Session
• Individual 10-question MCQ (Canvas)

Lab Activities
• Vital signs practice within teams
• Individual assessment with TA/facilitator

Post-Lab Activities
• Big Blue Button Debrief

Each section = 30 to 35 students
Students remain in teams of 4 to 7 students
TOP 200 DRUGS CURRICULAR THREAD

First professional year
- Brand name(s)
- Generic name(s)
- Drug class (e.g., antihypertensive, antidepressant)
- Indication(s)

Second professional year
- Common doses and dosage forms
- Patient counseling points
- Pharmacology
- DEA schedule (if controlled substance)

Third professional year
- Pharmacokinetic information
- Common drug interactions
- Major contraindications or precautions
- Adverse effects

MCQ examination at the end of each semester (n=6) (100 out of 200 total drugs on each exam)
Fall 2015
Odd-numbered teams (n = 122 students)

15 MCQs

2 MCQs every 2 days

Fall exam

Spring 2016
Even-numbered teams (n = 114 students)

15 MCQs

2 MCQs every 2 days

Spring exam

50 MCQs

7 days

14 days

7 days

14 days

75 MCQs
Mr. Gatsby brings a prescription to the pharmacy from his doctor. The prescription is written for Lasix and is allowed to be automatically substituted with a generic. Which generic medication would be substituted for Lasix?

**Choices**

- Triamterene with hydrochlorothiazide
- Spironolactone
- Furosemide
- Hydrochlorothiazide

Submit
Mr. Gatsby brings a prescription to the pharmacy from his doctor. The prescription is written for Lasix and is allowed to be automatically substituted with a generic. Which generic medication would be substituted for Lasix?

<table>
<thead>
<tr>
<th>Choices</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>You</strong></td>
<td>Triamterene with hydrochlorothiazide</td>
</tr>
<tr>
<td><strong>Key</strong></td>
<td>Spironolactone</td>
</tr>
<tr>
<td>Furosemide</td>
<td>90%</td>
</tr>
<tr>
<td>Hydrochlorothiazide</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Results**

Congratulations, your answer is correct!

This question will be resent on 11/09/16

Your total score: 550

You just scored 50 points for answering correctly on your first attempt of this question. On track for bonus points. Answer correctly on your next attempt of this question for a bonus of 100 points.

**Explanation**

Furosemide is the generic name for Lasix and can be automatically substituted in the state of Florida unless the physician writes "Dispense as Written" on the prescription. Hydrochlorothiazide is the generic name for Microzide, spironolactone is the generic name for Aldactone, and triamterene with hydrochlorothiazide is the generic name for Dyazide or Maxzide. All listed choices are classified as diuretics.
REPORTING FEATURES

<table>
<thead>
<tr>
<th>Question</th>
<th>Total responders</th>
<th>Total responses</th>
<th>Total retired</th>
<th>Initial correct</th>
<th>Initial incorrect</th>
<th>Current correct</th>
<th>Current incorrect</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antanginal</td>
<td>233 (81%)</td>
<td>424</td>
<td>182</td>
<td>224 (96.14%)</td>
<td>9 (3.86%)</td>
<td>232 (99.57%)</td>
<td>1 (0.43%)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Initial presentation responses**

To indicate how your question is performing the table below shows the distribution of responses on first presentation of the question.

<table>
<thead>
<tr>
<th>Key</th>
<th>Choices</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td>Pravastatin</td>
<td>0%</td>
</tr>
<tr>
<td>✓</td>
<td>Nitroglycerin</td>
<td>95%</td>
</tr>
<tr>
<td>✗</td>
<td>Atenolol</td>
<td>0%</td>
</tr>
<tr>
<td>✗</td>
<td>Verapamil</td>
<td>3%</td>
</tr>
</tbody>
</table>

Mr. Charlie Brown calls to request a refill of his Nitroquick. Which of the following generic medications would you select from Mr. Brown’s profile to refill?

234 responses
Student and Cohort Performance
- Student engagement in the challenge
- % Improvement between initial and current attempt

Top 200 Examination Data
- Overall examination performance
- Performance on subset of Cardiovascular agents in Fall and Spring

Self-Efficacy and Perception Data
- Online 16-item survey (retrospective pre-post design)
- Qualitative comments
**ACTIVITY #2**

- Think back to the game-based strategy you implemented or wish to implement. How would you measure its effectiveness? (Think back to Kirkpatrick’s model)

<table>
<thead>
<tr>
<th>Learning objective(s)</th>
<th>Game-strategy</th>
<th>Reactions</th>
<th>Learning</th>
<th>Behavior</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design a treatment plan for a patient with T2DM.</td>
<td>Escape room survey</td>
<td><em>Pre-activity quiz</em>&lt;br&gt;<em>Post-activity quiz</em>&lt;br&gt;<em>Did they retain it?</em>&lt;br&gt;-Immediate post-test&lt;br&gt;-Delayed post-test</td>
<td></td>
<td>Diabetes Objective Structured Clinical Examination (OSCE)</td>
<td>Chart audit of diabetes patients to evaluate treatment plans OR Patient outcomes (A1c, satisfaction)</td>
</tr>
<tr>
<td>2. Explain appropriate treatment of hypoglycemia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# SUMMARY OF RESULTS

**Impact of Using QStream® to Study Top 200 Drug Information (N=236)**

<table>
<thead>
<tr>
<th><strong>Significantly improved performance on current vs. initial attempt</strong></th>
<th><strong>High levels of engagement across both semesters</strong></th>
<th><strong>Mean Top 200 Drug Examination Scores</strong></th>
<th><strong>Highest level of engagement (very active) had significantly higher mean exam scores than those who were active or who did not start the challenge</strong></th>
</tr>
</thead>
</table>
| 9/15 questions (Fall)
1/15 questions (Spring)
(p < 0.05 for each)
*McNemar’s test* | 83% (99/122) very active or active (Fall)
73% (84/114) very active or active (Spring) | 96.8% (Fall)
93.8% (Spring) | Fall semester only
*Kruskall-Wallis test* |
## SUMMARY OF RESULTS

<table>
<thead>
<tr>
<th>Impact of Using QStream to Study Top 200 Drug Information (N=236)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No differences in semester of allocation to QStream® and fall or spring Top 200 Drug examination scores</strong></td>
</tr>
<tr>
<td><em>Mann-Whitney U test</em></td>
</tr>
<tr>
<td><strong>No differences in student performance on cardiovascular drug subset on the fall or spring examination based on assigned semester of QStream®</strong></td>
</tr>
<tr>
<td><em>Mann-Whitney U test</em></td>
</tr>
</tbody>
</table>
## Summary of Results

**N = 38 (17% response rate)**

*Wilcoxon signed rank test*

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Confident/Very Confident, No. (%)</th>
<th>Likert Score, Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-</td>
<td>Post-</td>
</tr>
<tr>
<td>Recognize the brand name of commonly used medications in the community pharmacy setting</td>
<td>6 (15.79%)</td>
<td>20 (52.63%)</td>
</tr>
<tr>
<td>Recognize the generic name of commonly used medications in the community pharmacy setting</td>
<td>7 (18.42%)</td>
<td>23 (60.53%)</td>
</tr>
<tr>
<td>Define the common indication(s) of commonly used medications in the community pharmacy setting</td>
<td>4 (10.53%)</td>
<td>23 (60.53%)</td>
</tr>
<tr>
<td>Define the medication class of commonly used medications in the community pharmacy setting</td>
<td>3 (7.89%)</td>
<td>24 (63.16%)</td>
</tr>
</tbody>
</table>
## Summary of Results

<table>
<thead>
<tr>
<th>What Students Liked Most</th>
<th>What Students Liked Least</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question Format</strong></td>
<td></td>
</tr>
<tr>
<td>“I liked the scenarios. They were entertaining yet very educational.”</td>
<td><strong>Number of Questions</strong></td>
</tr>
<tr>
<td></td>
<td>“I wish there were more questions available.”</td>
</tr>
<tr>
<td><strong>Immediate Feedback</strong></td>
<td></td>
</tr>
<tr>
<td>“Always available, instant feedback on answer choice.”</td>
<td><strong>Lack of Question Variation</strong></td>
</tr>
<tr>
<td></td>
<td>“There is not a lot of question indication variation.”</td>
</tr>
<tr>
<td><strong>Competition</strong></td>
<td></td>
</tr>
<tr>
<td>“I liked that it was a competition with my classmates”</td>
<td><strong>Frequency of Question Delivery</strong></td>
</tr>
<tr>
<td></td>
<td>“It’s better if they ask questions more frequently…”</td>
</tr>
<tr>
<td><strong>Fun</strong></td>
<td></td>
</tr>
<tr>
<td>“It was designed to have fun while studying”</td>
<td><strong>Lack of Open Access</strong></td>
</tr>
<tr>
<td></td>
<td>“I wish the QStream challenge was available every day.”</td>
</tr>
<tr>
<td><strong>Prompting to Study</strong></td>
<td></td>
</tr>
<tr>
<td>“QStream sent me questions to practice.”</td>
<td><strong>Email notifications</strong></td>
</tr>
<tr>
<td></td>
<td>“Getting emails at 4:30 am was annoying.”</td>
</tr>
</tbody>
</table>
# SUMMARY OF RESULTS

## Impact of Using QStream® to Study Top 200 Drug Information (N=38)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Percentage Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowed study at times they wouldn’t normally study</td>
<td>59.5% agreed or strongly agreed</td>
</tr>
<tr>
<td>Allowed study in places they wouldn’t normally study</td>
<td>62.2% agreed or strongly agreed</td>
</tr>
<tr>
<td>Preferred QStream® to Sigler Drug Cards for study</td>
<td>67.8% agreed or strongly agreed</td>
</tr>
<tr>
<td>Majority wished to use QStream® in other courses</td>
<td>83.8% agreed or strongly agreed</td>
</tr>
</tbody>
</table>
DISCUSSION

- Overall, students engaged in this voluntary study resource and had positive perceptions
- Did not effect top 200 drug examination performance or retention of top 200 drug knowledge for cardiovascular drug subset
  - High examination scores in both fall and spring semesters
  - Difficult to discern a difference?
- Use of the online spaced-education game has been shown to improve retention of clinical knowledge and examination scores in medical students and residents
FUTURE RESEARCH

- Evaluate differences in student engagement if participation is mandatory
- Factors that increase student engagement in self-directed educational games
- Use with more complex course material or more comprehensive Top 200 drug information
BACK TO OUR FRIEND JOE

A. Keep re-reading your lecture notes and assigned readings
B. Highlight key ideas from lecture notes and assigned readings
C. Summarize key points in the margins of your readings or lecture notes
D. Complete practice multiple-choice tests on the material
DEBRIEF AND Q&A
ADDITIONAL RESOURCES

make it stick
The Science of Successful Learning
Peter C. Brown
Henry L. Roediger III
Mark A. McDaniel

THE GAMIFICATION
OF LEARNING AND INSTRUCTION
GAME-BASED METHODS AND STRATEGIES
FOR TRAINING AND EDUCATION
KARL M. KAPP

THE GAMIFICATION
OF LEARNING AND INSTRUCTION
FIELDBOOK
Ideas into Practice
THANK YOU FOR YOUR ATTENTION!