TEACHERS' TOPICS

Crossword Puzzles as a Tool to Enhance Learning About Anti-Ulcer Agents

Samit Shah, PhD, Launa M. J. Lynch, PhD, and Lilia Z. Macias-Moriarity, PhD

South University School of Pharmacy, Savannah, GA

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Objective. To design, implement, and evaluate the use of crossword puzzles as a low-stakes educational tool for enhancing learning about anti-ulcer agents.

Design. Crossword puzzles were created using a free Internet resource and administered to students during 3 consecutive lectures covering the pharmacology and medicinal chemistry of anti-ulcer agents. Student perceptions of the crossword puzzle were examined using an 8-item survey instrument.

Assessment. Over 90% of students indicated that crossword puzzles enhanced their learning, oriented them to the important topics, and served as good reviews of the lecture material.

Conclusion. Students perceived that crossword puzzles enhanced their learning of anti-ulcer agents. Use of crossword puzzles provides a simple and creative way to incorporate active learning into pharmacy classroom instruction.

Keywords: crossword puzzles, active learning, anti-ulcer agents, games, pharmacology, medicinal chemistry

INTRODUCTION

Much of the material delivered to students in the pharmacy curriculum is through “presentation” of factual information via passive teaching methods.^{1,2} Incorporation of active-learning methods into classroom instruction allows lecturers to engage students in the learning process and enhance their learning experience.^{1,3,4} Use of games in the pharmacy classroom is an effective way of introducing active learning in the classroom.^{5,6} Games such as “PK Poker” and “Who Wants to Be a Med Chem Millionaire?” offer a resourceful supplement to lecturing and provide a positive learning experience for students. Crossword puzzles also are useful as structured educational tools for facilitating critical thinking and reinforcing the material acquired during the lecture.^{4,7-9}

South University School of Pharmacy presents important material in the pharmacy curriculum in integrated sequence modules. Examples of the integrated sequence modules are: infectious disease, inflammation, gastrointestinal/hepatobiliary, endocrine, and cardiology. The use of organ-system-based modules allows lecturers from the pharmacology, medicinal chemistry, and therapeutics disciplines to deliver lecture material in an integrated and sequential manner. Crossword puzzles were used in the integrated sequence module covering gastrointestinal dis-

eases during 3 lectures focusing on the pharmacology and medicinal chemistry of anti-ulcer agents. Crossword puzzles were designed to provide students with feedback regarding their understanding of the material presented in the lecture and to promote student involvement in the learning process. This article describes the use of crossword puzzles in lectures covering the pharmacology and medicinal chemistry of anti-ulcer agents and includes student evaluation of the crossword puzzles as a low-stakes educational tool for enhancing student learning.

DESIGN

Using a free online resource,¹⁰ crossword puzzles were designed for 3 lectures describing the pharmacology and medicinal chemistry of anti-ulcer agents (Figure 1). These lectures were part of the gastrointestinal integrated sequence course, which met biweekly for 75 minutes in a 10-week quarter. Specific learning objectives for each of the 3 lectures are summarized in Table 1.

Definitions of terms introduced in class and specific information such as chemical properties and side effects of drugs presented in the lecture were supplied as “down” or “across” clues to solve the crossword puzzle. The puzzle clues were developed in alignment with the learning objectives for the lecture. Since the first lecture on anti-ulcer agents covers an introduction to ulcers, the molecular mechanism of gastric acid secretion, an overview of the treatment options, and specific antacids used in the clinic, the crossword was designed to test each of these topics (Figure 1). Covering information from each of the

Corresponding author: Samit Shah, Ph.D., South University School of Pharmacy, 709 Mall Boulevard, Savannah, GA 31406. Phone: 912-201-8155. Fax: 912-201-8153. E-mail: sshah@southuniversity.edu

Table 1. Specific Learning Objectives for the Three Lectures Covering Anti-Ulcer Agents

Lecture 1

- Recall the pathophysiology and symptoms of peptic ulcer, duodenal ulcer and GERD
- Describe agents responsible for causing ulcers and their mechanisms
- Describe cellular factors that offer protection against ulcers
- Explain the molecular mechanism of acid secretion in detail
- List the drug classes used to treat ulcers and describe briefly how they act
- Describe antacids, their mechanism of action and the specific antacids used clinically
- Describe specific properties and side-effects of the antacids used clinically
- Distinguish between an agonist & an antagonist
- Explain the mechanism of action of H₂ receptor antagonists

Lecture 2

- Describe the chemical properties and tautomers of histamine
- Discuss the development of 4-methylhistamine, burimamide and metiamide from histamine and explain how they led to the development of cimetidine
- Illustrate how studying intermediates leading to cimetidine helps in understanding the role of the different functional groups in cimetidine
- Describe the specific side-effects, uses, drug interactions, properties and metabolism of cimetidine, ranitidine, famotidine and nizatidine
- Apply SAR to predict clinical and pharmacological activity of H₂ receptor antagonists
- Describe the mechanism of action, chemistry, metabolism, use and adverse effects of prostaglandins as anti-ulcer agents

Lecture 3

- Describe the H⁺/K⁺ ATPase pump and explain the mechanism of action of proton pump inhibitors (PPIs)
 - Compare and contrast the mechanism and extent of acid release inhibition achieved by H₂ receptor antagonists and PPIs
 - Describe the important components of the PPI pharmacophore
 - Explain PPI activation in acidic medium
 - Calculate the protonation states of acidic and basic functional groups using the Henderson-Hasselbalch equation
 - Explain the importance of pyridine and benzimidazole protonation states for parietal cell accumulation and for PPI activation
 - Describe the specific chemistry, uses, side-effects, drug interactions, properties and metabolism of omeprazole, esomeprazole, lansoprazole, pantoprazole and dex-lansoprazole
 - Apply the understanding of chemistry to predict the clinical and pharmacological activity of PPIs
 - Describe the mechanism of action, chemistry, metabolism, use and adverse effects of sucralfate as an anti-ulcer agent
 - Describe the mechanism of action, chemistry, metabolism, use and adverse effects of colloidal bismuth compounds as anti-ulcer agents
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important lecture topics in the crossword puzzle provided feedback to the students on those areas on which they needed to spend more time. The clues given to the students were created at a moderate difficulty level as more difficult puzzles may have discouraged students from participating in the activity.⁴

Printed copies of the crossword puzzles were handed out to the students at the beginning of the class. Students were asked not to complete the puzzles until told to do so by the lecturer. When all of the pertinent material covered in the crossword puzzles had been presented in the lecture (approximately 45-55 minutes into the class), the students were given 5 minutes to complete the puzzle. Students were encouraged to interact with each other while completing the puzzle to promote cohesive learning and identify misconceptions students had about the lecture material. After 4 minutes, when a majority of students had finished

solving the crossword puzzle, the lecturer announced that 45-60 seconds were remaining. The lecturer then continued with the remaining part of the lecture.

Since one of the advantages of a crossword puzzle is its unique characteristic of self-correcting due to the length of each word and the overlap of each answer with other answers, the correct answers were not discussed in class.⁴ No credit towards the final grade was given to the students for completion of the crossword puzzles and students were not required to turn in the crossword puzzles. Students who could not complete the puzzles in class were encouraged to read the material and complete the puzzle outside of class and contact the lecturer if they needed assistance.

EVALUATION AND ASSESSMENT

Two groups of students enrolled in the gastrointestinal course completed 3 crossword puzzles, 1 during each of

Figure 1. An example of a crossword puzzle created to enhance student learning of anti-ulcer agents.

3 consecutive gastrointestinal lectures. The first group, the graduating class of 2010, was enrolled in fall 2008. The second group, the graduating class of 2011, was enrolled in fall 2009. An anonymous survey instrument was developed to assess both groups' perceptions of crossword puzzles as a tool to enhance learning, identify key information, and serve as a review of material covered. The instrument was composed of 8 statements with a 5-point Likert scale used for responses (disagree-agree). In addition to assessing the students' perception of the use of crossword puzzles as a tool to enhance their learning experience, the survey instrument was intended to gather information about *how* crossword puzzles provided a positive learning experience and to determine what changes should be made in how the crossword puzzles were administered in the future. The items "crossword puzzles provided enhanced my learning" and "learned more in class because of the crossword puzzles" were designed to measure the students' perception of the crossword puzzles as a way to enhance their learning experience. The items "enjoyed classmate interaction and reviewing material while solving puzzle," "crossword puzzles oriented us to the topics we should focus on," and "solving crossword puzzles are good reviews of the material covered" were developed to capture student perceptions of why they believed the crossword puzzles provided an enhanced learning experience. The remaining 3 items "length of time provided for solving

the puzzles was sufficient," "the material on the puzzles was pertinent," and "extra credit should be associated with activities such as crossword puzzles" were developed to examine whether the students believed that changes were needed to the way the crossword puzzles were created and administered.

Both groups completed the survey instrument only once. In 2008, the student perception survey instrument was administered at the end of the third lecture. In 2009, the perception survey instrument was administered at the end of the course, 8 weeks after the lectures covering the pharmacology and medicinal chemistry of anti-ulcer agents.

Over 80% of all students completed the survey instrument (66 of 82 in 2008 and 78 of 90 in 2009). Students strongly supported the use of crossword puzzles in the classroom (Table 2). All students in 2008 and 92% of the students in 2009 indicated that crossword puzzles enhanced their learning. One hundred percent of the students in 2008 and 95% in 2009 agreed or strongly agreed that the crossword puzzles helped them learn the important topics within the lectures. Also, 95% of students in 2008 believed that they learned more as a result of the crossword puzzles versus 78% in 2009. Over 99% of students reported that crossword puzzles were good reviews of the lecture material. In terms of class interaction, most students enjoyed engaging their classmates while solving the puzzle (98% in 2008 and 88% in 2009). Students opinions about the concept of earning extra credit for the crossword puzzles varied, with 15% in 2008 and 26% in 2009 disagreeing with the idea. In addition to the 8 survey items, students were asked to provide additional comments about the crosswords if they desired.

The student comments were generally favorable and provided insight into the positive learning experience perceived by the students. The students described the crossword puzzles as being a fun and unique way to test their comprehension of the material. The students pointed out that completing the crossword puzzles provided a good review of the material covered in class and allowed them to communicate and discuss the material with their classmates. A couple of students pointed out that the crossword puzzles should be bigger and that students were provided too much time for solving the puzzles.

Achievement of learning outcomes was assessed through the use of examinations consisting of multiple-choice questions. Performance on the examinations related to the pharmacology and medicinal chemistry of anti-ulcer agents represented 42% of the test in 2008 and 50% of the test in 2009. The remainder of both tests covered questions related to the therapeutics of anti-ulcer agents. In 2008, the test average was 82%, and in 2009 the average on the test was 85%.

Table 2. Student Perceptions of Crossword Puzzles as a Study Tool (N=144)

Question	Year	No.	Mean (SD)	Responses, %				
				Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Crossword puzzles provided enhanced my learning	2008	66	4.7 (0.5)	-	-	-	30.3	69.7
	2009	78	4.4 (0.7)	-	1.3	6.4	47.4	44.9
Enjoyed classmate interaction and reviewing material while solving puzzle	2008	66	4.6 (0.7)	1.5	-	-	33.3	65.2
	2009	78	4.3 (0.7)	-	-	11.5	47.4	41
Crossword puzzles oriented us to the topics we should focus on	2008	66	4.7 (0.5)	-	-	-	33.3	66.7
	2009	78	4.5 (0.6)	-	-	5.1	41	53.8
Length of time provided for solving the puzzles was sufficient	2008	66	4.4 (0.6)	-	-	4.5	47	48.5
	2009	78	4.4 (0.6)	-	-	5.1	46.2	48.7
The material on the puzzles was pertinent	2008	66	4.6 (0.5)	-	-	-	36.4	63.6
	2009	78	4.6 (0.5)	-	-	1.3	38.5	60.3
Learned more in class because of the crossword puzzles	2008	66	4.5 (0.6)	-	-	4.5	40.9	54.5
	2009	77 ^a	4.0 (0.8)	-	2.6	19.5	45.5	32.5
Solving crossword puzzles are good reviews of material covered	2008	66	4.7 (0.5)	-	-	-	28.8	71.2
	2009	78	4.5 (0.5)	-	-	1.3	44.9	53.8
Extra credit should be associated with activities such as crossword puzzles	2008	65 ^a	4.5 (0.8)	-	1.5	13.8	20	64.6
	2009	78	4.2 (1.0)	1.3	5.1	16.7	23.1	53.8

^a 1 missing response.

The course was evaluated by students at the end of the quarter as part of the assessment plan in place at the school. The evaluations were done by paper using a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree). Student course evaluations related to the anti-ulcer topic were positive. The students agreed with the statement “The assignments and quizzes contributed significantly to learning,” with a mean score of 4.7 in 2008 and a mean score of 4.3 in 2009. Likewise the students generally agreed with the statement “I have developed an understanding of the principles of medicinal chemistry, pharmacology, and therapeutics as these disciplines relate to the molecular interactions of drugs with biological systems and the fundamentals of rational drug therapy in clinical settings” with a mean score of 4.5 in 2009 and 4.3 in 2009.

DISCUSSION

The goal of our survey was to examine pharmacy students' perception of crossword puzzles as creative and interactive educational materials to enhance their learning experience. The student responses to the 8-question survey captured the multiple benefits of crossword puzzles as supplements to traditional lecture formats. Students reported that crossword puzzles helped them to identify important topics and served as a good review of the material covered. A majority of students also believed that crossword puzzles enhanced their learning. The results from our survey are consistent with previous studies examining the effectiveness and student perception of crossword puzzles as study tools.^{4,7} Saxena et al found that crossword puzzles

contributed to the overall learning of 61 of 80 medical students in an undergraduate pathology course.⁴ While this manuscript describes the student perceptions of the use of crossword puzzles as an active-learning instructional tool, the value of crossword puzzles as an educational tool can also be measured by examining the effect of crossword puzzles on student learning by comparing performance of student groups' who had completed the puzzles in lectures versus those who had not. Crossman and Crossman showed that students achieved higher test scores in a History of Psychology course after using crossword puzzles as study tools.⁷

Many students indicated that the crossword puzzles helped them to focus on the important topics in the lectures and provided a good review for the examination. Others noted that the crossword puzzles made learning fun as they were interactive, enjoyable, and provided a nice change “from the typically dry nature of certain subjects.” Some students also indicated that solving the crossword puzzles led them to start studying sooner for the examinations and helped them learn some topics from the lecture that they might have otherwise overlooked. Another factor that may have contributed to the positive learning experience perceived by the students is that at least 90% of students surveyed in 2008 and 2009 are Millennials, students who were born from 1980-1991.¹¹ Oblinger described Millennials as participatory learners who prefer to assemble information from a variety of sources. Crossword puzzles allow students to participate in the learning process by challenging and identifying

gaps in their knowledge in an interactive format.⁴ More than 95% of students enjoyed interacting with classmates and reviewing the material while solving the puzzle. This is in line with Oblinger's description of Millennials as communicators who gravitate toward activities that promote and reinforce social interaction.

A contributing factor to the enhanced learning experienced by the students also may have been the pause in the lecture itself. Adult learners have an attention span of around 20 minutes; thus, didactic lectures should be punctuated with periodic activities to restart the "attention clock."¹² Lecturers who can incorporate illustrations, experiments, or other types of breaks into a lecture can command increased attention from students.¹³ Crossword puzzles provide a good break in a lecture as they are traditionally associated with being a recreational activity. Additionally, the advantage of using the crossword puzzles as a "break" is that it allows students to continue their learning. Involvement in a different activity might also improve the attention span of the students for the remaining part of the lecture and ensure that students review the key concepts covered in class. This is especially helpful in teaching sequential material where the knowledge of basic concepts covered in the early portion of a lecture is essential to build understanding of the latter portion. Simply addressing the key points during a mid-lecture summary slide does not necessitate all passive learners to focus and review the key concepts presented in the lecture. The crossword puzzles require the students to read through the clues, recall and review the material, and engage in discussions with their colleagues to clear any misconceptions about the material.⁴ This most likely leads to a better comprehension and retention of the learning material and contributes towards the positive learning experience perceived by the students. While this manuscript focuses on the use of crossword puzzles to incorporate active learning in the pharmacy classroom, other activities such as word scrambles, word search puzzles, Jeopardy, and bingo may be equally effective in increasing student involvement in the learning process.

SUMMARY

Crossword puzzles were used as an in-class activity for 3 consecutive lectures on anti-ulcer agents. Student perceptions of the use of crossword puzzles as an active-learning instructional tool were gathered using a survey

instrument based on a 5-point Likert scale. A majority of the students perceived that the crossword puzzles enhanced their learning of antiulcer agents. Crosswords contributed to a positive learning experience by allowing the students to better engage in the learning experience, providing a recreational break during the lecture, and allowing the students to review the lecture material. Crossword puzzles are easy to create using tools available on the Internet and offer a simple and creative way to incorporate active learning into a number of courses in the pharmacy curriculum.

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