Utility of Self-Made Crossword Puzzles as an Active Learning Method to Study Biochemistry in Undergraduate Education

By Sulekha Rao Coticone

To incorporate an active learning component in a one-semester biochemistry course, students were asked to create crossword puzzles using key concepts. Student observations on the use of self-made crossword puzzles as an active-learning instructional tool were collected using a 5-point Likert survey at the end of the semester. A majority of the students felt that the crossword puzzles enhanced their learning of biochemical concepts. Constructing their own crosswords contributed to a positive experience by allowing the students to better engage in the learning experience. In addition, multiple-choice questions using clues from the crossword puzzles were also incorporated into the final examinations. Therefore, self-made crossword puzzles offer a simple and creative way to incorporate active learning into a number of courses in the biochemistry curriculum.

The understanding and comprehension of biochemical terms can be a daunting task for most students of one-semester biochemistry classes. Students are expected to grasp important terms in a fast pace before they understand the actual mechanism and function of various biomolecules. Much of this information is provided to students by “passive method” in the form of notes, PowerPoint presentations, etc. With changing trends in medical education, it is necessary to provide students with alternate methods of learning (Htwe, Sabaridah, Rajyaguru, & Mazidah, 2012). Active learning refers to an education model of instruction that emphasizes the responsibility of learning on the student (Bonwell & Eison, 1991). Introduction of active learning methods provides instructors with an opportunity to engage students and thereby enhance their learning process (Bailey, Hsu, & DiCarlo, 1999; Dimmock, 2000; Roche, Alsharif, & Ogynbadeni, 2004). Games and puzzles have been demonstrated to be effective methods of the active learning process (Persky, Stegall-Zanation, & Dupuis, 2007; Poston, 1988). Games such as “Jeopardy” provide students with a structured but positive learning experience. These games and puzzles facilitate important critical-thinking skills while reinforcing concepts taught in classes (Childers, 1996; Eckert et al., 2004).

In the present study, students were invited to design their own crossword puzzles (a) to provide feedback regarding their understanding of the material presented in the lecture and (b) to promote student involvement in the learning process. This article describes the use of crossword puzzles in lectures covering a one-semester biochemistry course and includes student evaluations of the process of generation of the crossword puzzles as an educational tool for enhancing their learning.

Methods

Students were asked to design their crossword puzzles in the one-semester biochemistry course offered at the university. The course met bi-weekly for 2 hours and 15 minutes during a 15-week semester. Students were provided study guides for each chapter that contained important terms and comparisons sections. These could be used to construct the “across” and “down” clues to solve the crossword puzzle. Instructions on how to construct the puzzle are shown in Figure 1. To evaluate the activity, students completed an eight-question survey using a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree). An example of a student-generated crossword puzzle is shown in Figure 2. All exams contained two components: (a) a 30-point multiple-choice section and (b) a 70-point critical-thinking section. Terminology questions re-
lated to crossword puzzle clues were incorporated in the multiple-choice section. An example of a terminology-related question linked to the “Across 24” crossword puzzle clue is shown below:

1. Which of the following help in the regulation of membrane fluidity?
   A. Protein
   B. Cholesterol
   C. ATP
   D. Magnesium ions
   E. None of the above

Assessment

Two groups of students (30 students each) enrolled in the biochemistry course constructed crossword puzzles at the end of the semester before the comprehensive final exam. Students were invited to generate crossword puzzles as extra credit (5 points added to the final exam). The first group of students was enrolled in spring 2011 and a second group in fall 2011. In addition data was used from two groups of students (spring 2009 and spring 2010) as control groups where no crossword puzzles were generated; instead, equally weighted extra credit was provided by more passive methods (e.g., short essays). An anonymous survey was developed to determine why they believed the crossword puzzles provided an enhanced learning experience. Finally, the questions “was an entertaining way to boost my understanding” and “I would enjoy making more crossword puzzles” were introduced to determine if students found building crossword puzzles to be a fun way of learning biochemistry terms.

The evaluations were done using a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree). Students were enthusiastic about the use of crossword puzzles in the classroom. All students in fall 2011 and 95% of students in spring 2011 agreed or strongly agreed that building crossword puzzles enhanced their learning of biochemistry (Table 1). Also, 95% of students in spring 2011 believed that crossword puzzles improved their knowledge of biochemistry vocabulary versus 100% in fall 2011. Over 85% of students stated that crossword puzzles helped them retain the biochemistry content. All students reported that building crossword puzzles facilitated recall as well as required them to read and or study vocabulary terms. Student opinions on whether self-made crossword puzzles were a useful tool to build vocabulary or whether they would enjoy making more puzzles varied from 85% to 100%. Students voluntarily provided additional comments about the crosswords that were positive.

Final examination scores and class averages were used as a proxy to measure the effectiveness of the use of self-made puzzles. For the control group, the class average was 79.4 + 0.27. In contrast, for the crossword puzzle groups the average score was 80.9 + 0.46. Therefore, either no change or an improvement in scores can be attributed to the construction of crossword puzzles. On the basis of these observations, the incorporation of self-made crossword puzzles did not appear to be detrimental to student learning.

Discussion

The goal of our survey was to examine biochemistry students’ perception of crossword puzzles as creative and interactive educational materials to enhance their learning experience.

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FIGURE 1

Rules and instructions for extra-credit crossword puzzle.

Rules and instructions:

1. The puzzle must include at least 20 entries, in any combination of across and down.
2. Color in the boxes that are not used.
3. Your submission must include an unsolved puzzle, a numbered clue list (divided into “across” and “down” lists) and a solved version of your puzzle.
4. Clues must be short, a few words.
5. All entries must intersect at least one other entry.
6. Use only biochemistry terms and concepts learned this semester.

Tips:

Start by writing a list of possible words, include short, medium, and long words. When designing your puzzle, start with one long word in the middle and work out from there instead of starting in a corner.
Biochemistry crossword puzzle created by a student.

Across

2. _______containing amino acids coding for Methionine and Cysteine
6. This sequence determines the folding of the proteins
8. Another name for fixation of ammonia into amino acids
12. Size exclusion, ion exchange, affinity
15. Experiment where a measured amount of base is added to a measured amount of acid
18. Rho _______bumps polymerase off to terminate transcription because of hairpin shape
24. Steroid factor affecting membrane fluidity
25. Made by ester linkages between fatty acids and glycerol
26. Uncoupling oxidation and phosphorylation; occurs in adipose tissue
27. _______acid present in broccoli and spinach; prenatal care to prevent spina Bifida
28. Type of inhibition used to regulate nucleotide biosynthesis
29. Three-dimensional structure of protein

Down

1. Which sugar has 1, 2 beta glycosidic linkages and is nonreducing?
3. Term used to describe both hydrophobic and hydrophilic regions
4. Occurs in skeletal muscle with lack of oxygen
5. Made of 4 subunits; 2 alpha helices and 2 beta sheets
6. Uses energy for light to boost electrons from a low to high energy state
7. What type of carbohydrates are cellulose, starch, and glycogen?
9. Biosynthesis nucleotide pathway where bases are recovered and reconnected to a ribose unit
10. Reversible inhibition that competes for same binding site
11. D- and L- glyceraldehyde are called?
13. Pharmaceutical membrane used to hold drugs in inner aqueous compartment
14. Number used to determine substrate molecules converted to product when fully saturated.
16. _______-aspartate is used as an electron shuttle primarily in the heart and liver
17. pH and _______ are factors affecting enzyme activity
19. Allosteric model: binding of substrate molecules converts to conformational change
20. Small molecules react to produce larger molecules
21. Essential amino acid residue; Serine_______ enzyme
22. Antibiotic: type of suicide inhibitor
23. Converts 1 molecule of glucose to 2 molecules of pyruvate
The student responses to an eight-question survey exemplified 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.

In a previous study, crossword puzzles were found to contribute to the overall learning of medical students in an undergraduate pathology course (Saxena, Nesbitt, Pahwa, & Mills, 2009). In addition, students have been shown to achieve higher scores after using crossword puzzles (Crossman, 1983). Crossword puzzles allow students to participate in the learning process by challenging them and identifying gaps in their knowledge in an interactive format.

This study is unique because students were asked to build their own crossword puzzles compared with previous studies of students being asked to solve crossword puzzles. This may be important because the present generations of students are “active” learners. The crossword puzzles require the students to build their own clues by reviewing the material, thereby removing any misconceptions about the material. This promotes better understanding and knowledge of the material, contributing to the positive learning experience. Future studies could involve asking groups of students to generate puzzles followed by a puzzle-solving swap. This would involve groups solving puzzles in a limited amount of time, thus increasing collaboration and competition. Although this study focuses on the use of crossword puzzles to incorporate active learning in the biochemistry classroom, other activities such as word scrambles, word-search puzzles, Jeopardy, and bingo may also be effective in increasing student involvement in the learning process.

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<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Eight-question survey results for spring 2011 and fall 2011.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly agree</td>
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<tr>
<td><strong>Spring 2011</strong></td>
<td></td>
</tr>
<tr>
<td>Enhanced my knowledge of biochemistry</td>
<td>38.1</td>
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<tr>
<td>Improved my knowledge of the vocabulary</td>
<td>42.9</td>
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<tr>
<td>Helped me retain the content</td>
<td>28.6</td>
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<tr>
<td>Was an entertaining way to boost my understanding</td>
<td>52.4</td>
</tr>
<tr>
<td>Facilitated my recall of the vocabulary terms</td>
<td>61.9</td>
</tr>
<tr>
<td>Required me to read and or study vocabulary terms</td>
<td>38.1</td>
</tr>
<tr>
<td>Was a useful tool to build vocabulary</td>
<td>33.3</td>
</tr>
<tr>
<td>I would enjoy making more crossword puzzles</td>
<td>57.1</td>
</tr>
<tr>
<td><strong>Fall 2011</strong></td>
<td></td>
</tr>
<tr>
<td>Enhanced my knowledge of biochemistry</td>
<td>61.9</td>
</tr>
<tr>
<td>Improved my knowledge of the vocabulary</td>
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</tr>
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</table>
Alvarado for the use of her crossword puzzle as an example.

References


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