Designing and Solving Crossword Puzzles: Examining Efficacy in a Classroom Exercise

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ABSTRACT

Using games in the classroom is an effective pedagogy. This paper examines both the creation and solution of crossword puzzles by students. Designing and solving puzzles requires several useful skills including the exercise of vocabulary, reasoning, and spelling. Although the use of crosswords in the classroom is not new, we propose an alternative view of the process by having students both design and solve puzzles. We evaluate this approach with case studies accompanied by results revealing the suitability of the exercise for undergraduate students. These findings show that students perceive themselves to be better equipped to handle concepts as a result of this crossword puzzle exercise.

INTRODUCTION

Using games in the classroom is an effective tool in the learning and teaching process. Educators have employed various experiential strategies in order to improve teaching effectiveness. One technique is to use crossword puzzles which can be tailored to the particular concepts of interest. This approach employs several useful student skills including vocabulary, reasoning, and spelling. In addition to the process of students solving puzzles, another important consideration is their involvement in the design process. Crossword puzzles can be used for teaching a specific subject especially since they can be adapted and tailored in limitless ways. The following sections discuss the conceptual framework promoting the use of games in the classroom, including crossword puzzles. Current approaches to crossword design and usage are presented. Further, evidence from case studies is presented, which reveals the effectiveness of this approach.

CONCEPTUAL FRAMEWORK

EFFECTIVE TEACHING STRATEGIES AND CLASSROOM GAMES

Ramsden (1992) proposes several key ideas to achieve classroom excellence through effective teaching strategies. These include:

1. *Interest and explanation*. **Instructors must establish content relevance, educator needs, and student skills related to the kind of information they understand, how they understand it, and how they forge connections between what is known and what is new**.
2. *Concern and respect for students and student learning*. **Educators must find ways to create a positive and** easy environment in the classroom. Good teaching has nothing to do with either making things difficult or intimidating for students (Weimer, 2006). The educator must help students feel that they are active participants in this process so that they are encouraged to try things on their own and potentially succeed more quickly.
3. *Appropriate assessment and feedback*. **Ramsden** recognizes the power of feedback for motivating student learning. Feedback involves a variety of assessment techniques and encourages students to demonstrate the acquired knowledge in several ways.
4. *Independence, control, and active engagement.* **A good educator must create tasks that align with the**

student's level of learning capability. As unique individuals, students will do better by avoiding the use of common practices. In such contexts, it is possible for students to live the experience and control their own learning process.

Using games in the classroom is a desirable learning method, which can transform learning into a less threatening and more enjoyable process for students and instructors alike (Franklin, Peat & Lewis, 2003; Weisskirch, 2006). Games add flexibility and interest to the classroom by allowing students to adjust to ways in which they learn best (Moore & Dettlaff, 2005). These kinds of activities also allow students to work either in groups or alone, to be competitive or not, to be creative, and to have fun learning (Davis, Shepherd & Zwiefelhofer. 2009).

The solving of crossword puzzles is considered to be entertainment, but is also a serious adult pastime (Eliot, 2001). Such puzzles were first introduced into newspapers in 1913 and since then it is difficult to find a newspaper without one. Two milestones in the history of crosswords are the publication in the *New York Times* of a Sunday puzzle in 1942 and a daily puzzle in 1950 (Frantz, 2007). Along with the standard crossword puzzle, newspapers today have word jumbles, word searches, cryptic crossword -puzzles, acrostics, and other word games.

There is little consensus about the date of introduction of crossword puzzles into the classroom, but the educational value of these puzzles seems to be widely recognized. Some publishers even include crossword puzzles as instructor resource material (cf. Daft, 2012, Cengage). One of the important considerations in this process is the capability to adapt and customize puzzles to the subjects being covered. The advent of the computer and internet has allowed easy access to various online programs for efficiently creating customized crossword puzzles.

SUPPORT FOR THE COGNITIVE AND SOCIAL DEVELOPMENT OF STUDENTS

Students must be able to know and understand the terminology of a particular subject in order to solve a related crossword puzzle. In the process of completing a puzzle, students can experience or exercise one or more of the following:

1. Acquiring new vocabulary or terminology
2. Making differentiations between similar words
3. Correctly spelling terms
4. Practicing dictionary-search and/or pronunciation skills
5. Making inferences
6. Evaluating choices
7. Developing logical thinking
8. Drawing conclusions
9. An appeal to their individual learning styles

In general, crossword puzzle solving can improve the social and academic skills of students (Lomas, 1999). This is attributed to the attention and concentration required for solving the puzzle, which leads to the exercise of the mind and ultimately the development of the intellect. According to Bello Cruz (1995), using crossword puzzles in an academic context permits the students to:

1. Acquire habits of collective decision making.
2. Improve interpersonal relationships and develop coexistence habits.
3. Acquire a high degree of interest.
4. Achieve durability in learning.
5. Develop continuity of thought.
6. Increase understanding and, therefore, develop the vocabulary.

Further, McKeachie (2002) suggests some advantages in the use of games like crossword puzzle solving because students play an active role, make decisions, solve problems, and react to the results of their own decisions. Olivares et al. (2008), recognize that crosswords are useful to reinforce self-esteem and develop professional skills. Other approaches propose using picture-based crossword puzzles to develop skills related to building teams in upper level courses (Dunphy & Whisenand, 2006).

SUPPORT FOR VOCABULARY BUILDING

In order to solve a crossword puzzle, a student must be able to identify, analyze, and understand the terms being used in a particular context. This process can involve learning vocabulary, terminology, or jargon, and differentiating among similar words or phrases. Klepper (2003) suggests a multi-process approach to learning or expanding vocabulary because it is more effective than using a single approach. Further, individuals differ in the ways they respond to stimuli as those impulses impact the retention and processing of information (Krätzig & Arbuthnott, 2006). The general recommendation is to provide a variety of resources to aid students in the learning process (Franklin *et al.*, 2003).

Whisenand and Dunphy (2010) promote the use of crossword puzzles as a vehicle to increase the speed of learning terms in introductory courses. Comprehending vocabulary requires active engagement with related ideas before achieving full understanding (Lewis, 2002) and crossword puzzles help students to master basic terminology (Kronholz, 2005).

SUPPORT FOR KNOWLEDGE BUILDING

Martín and Solbes (2001) suggest that deficiencies in educational methods contribute to difficulties in learning and understanding concepts. If a student barely learns the working definitions of concepts either by being unaware of meanings or being unable to differentiate concepts, confu-

sion and impediments arise. Since correctly solving a crossword puzzle requires precise spelling from the students, they are likely to reference their textbooks, articles, or basic theory sources more thoroughly. This may be especially true in the teaching of theory, as supported by the high percentage of wrong answers made by students in response to questions about theory (Furió & Guisasola, 1998). The ability to answer these types of questions requires both handling the learned theory and creatively applying knowledge.

SUPPORT FOR RECREATION AS A TEACHING STRATEGY

Solving crossword puzzles in the classroom suggests a recreational activity. In contrast to traditional classroom methods, puzzle solving can be entertaining and less intimidating. Students can play an active role, interact as team members, and engage with faculty. According to Cedeño (1995), a game is a recreational activity useful for developing skills, based on active participation from the students. Thus, learning can become a positive experience. Crossword puzzles are generally associated with game playing, fun, and recreation, and therefore can be less intimidating for students than other activities. Goh and Hooper (2007) conclude that using crossword puzzles taps unique motivation and challenges students to use lateral thinking skills. Other results show that students perceive the use of crossword puzzles as a fun way to learn specific material in a course.

THE GAME AND
EXPERIENTIAL RESULTS

The previous sections have offered evidence for the effective use of crossword puzzles in the classroom. However, none of the aforementioned studies relate to the creation and design of crossword puzzles as a student activity. Commonly, the puzzles are designed by the teacher or selected from an external source. Designing a crossword puzzle can be a challenging experience because students must develop knowledge of the related vocabulary accompanied by some capability to combine selected words with other words and acronyms. Although there exist various websites with applications for automatically designing crossword puzzles, the process here proposes constraints for minimizing the use of such applications. If the student engages in the manual design of a puzzle, the concepts will be attained more predictably and effectively. The following paragraphs describe the application of these constraints in the crossword puzzle classroom exercise.

The students are grouped in teams of 3 or 4 members. The terms and phrases used in the crossword puzzle must be taken from the concepts found in the textbook and related course materials. Teams are instructed to review and analyze the materials specifically assigned for this task in

order to identify relevant terms. They are offered guidelines for designing the crossword puzzle and presenting it for review purposes. The most important instructions follow:

1. The crossword puzzle will be designed in a 12x12 grid (preferable in a spread-sheet file).
2. Columns must be labeled with letters while rows must be labeled with numbers.
3. At least 15 terms extracted from the assigned paper must be used. The location of each term (page number and paragraph number) must be clearly established.
4. Up to 40 black cells can be used.
5. The remainder of any additional terms chosen for use must come from the materials used in this particular course.
6. If acronyms are used, they must be commonly used in the particular discipline.
7. All terms composed of two or more letters must have an accompanying definition.
8. The crossword puzzle must be presented in two versions: unsolved and solved (including the definitions or clues).
9. The file with the two versions must be uploaded one week before the scheduled date for the classroom game, in an area designated in the course learning platform.
10. Each term, word, or acronym can be used only once.

The crossword puzzles must be uploaded in the web-based learning platform so that the instructor can review them prior to the class and request revisions, as needed. The instructor subsequently ranks the puzzles according to quality such that the better crossword puzzles are used in the game before those of lesser quality. The game begins by having the designers of the top ranking puzzle act as the officials with the other teams acting as players. The order of participation is usually based upon the quality of the puzzle submitted, so that the stronger players go first. The first move by a team is to choose a playing position in the puzzle, after which the instructor reads the associated definition or clue. The officiating team manages the time and gives the playing team 60 seconds to answer. If the answer is correct, the officials write the answer inside the unsolved puzzle, record points, and turn to the next in line for their choice of playing position on the puzzle. If the given answer is incorrect, the turn is transferred to next team and no points are earned. The game is carried out in this manner until all the words are revealed. At the end of the game each team has earned a score equivalent to one point for each letter of each word that they correctly established on the puzzle. No points are awarded for letters previously revealed on the puzzle, so this serves as a motivator for teams to choose longer and perhaps more challenging words with letters that have not been previously revealed. Teams continue to play through the other available crossword puzzles, thus giving each team equal chance to earn

points across all the rounds. The final score for all rounds determines the winning team.

As a case study, this crossword puzzle activity was provided to students in three different sections of an undergraduate course in a systems engineering program. A total of 97 students participated and 26 of those had between two and four years of experience working in industry or at universities. Engineers in this program also take a course in industrial organization; although this exercise has not yet been conducted in the industrial organization class.

At the end of the study the players were asked to complete the game assessment survey adapted from McKenzie (2011) and Al-Issa (2009) to assess their perceptions of the experience of working with crossword puzzles. Using a pilot instrument, students indicated their extent of agreement with a set of statements on the 5-point and 3-point scales (cf. Trochim, 2006), as shown in Exhibit 1 with the points "definitely no," "probably no," "neutral," "probably yes," and "definitely yes;" and a 3-level scale with the grades "to a great extent," "somewhat," and "not at all."

The survey included 15 items divided into three separate blocks. The first 10 questions relate to personal perceptions about using and playing the crossword puzzles. These include positive or negative characteristics, insights, strengths, and weaknesses. The second block of 4 questions concerns the participant's perceptions about the design of crossword puzzles. The third section consists of one open-ended question about personal observations in order to obtain additional information from the participants. The survey given to the 26 more experienced students included two additional questions in the third section (see Exhibit 2).

The results showed that over 66% of the students rated the crossword puzzle activity to be an effective tool in learning a vocabulary and terminology (Probably Yes = 45.1% and Definitely Yes = 21.1%), and in improving their understanding and knowledge of introductory terms in the assigned materials (54.2%). The students deemed the use of crossword puzzle exercises to be a fun way to learn the material while playing a game (65.3%) and characterized the exercise as motivating, challenging, and competitive (59.2%).

The final survey question asked the participants to provide any additional comments about their experience with the exercise. The following sample statements presented below were selected from the 21 total comments submitted:

1. Using many acronyms is boring in a crossword puzzle; it is better to use more terms
2. Using crossword puzzles promotes team work
3. Students need more time to accurately develop the activity
4. More activities like this should be offered because this kind of activity is new and makes the class more dynamic
5. The guidelines to be fulfilled in designing the cross-

word puzzles were very difficult to achieve
6. It was a cool activity that makes the class different
7. The crossword puzzles should be slightly bigger to increase the level of complexity

While there were no serious objections found among the student comments, some important statements were made about the process used to conduct the game, the rules, the instructions, and frequency of using this type of method in class. By using a crossword puzzle exercise, instructors can provide an easy and engaging way to review terms and learn about specific content areas in their disciplines. Solving conceptually complex crossword puzzles requires the development of understanding and knowledge about an area.

The results associated with the perceptions of the more experienced students appear in Exhibit 2. In general, these results suggest that most of the more experienced students believe that the crossword puzzle exercise was an effective learning tool in the classroom. They felt that some knowledge and creativity was necessary to design crossword puzzles, but perhaps not as much as that perceived by the less experienced students. These students may have possessed advanced skills making the task seem less difficult; however, they still thought that the game, in general, was challenging. The more experienced students also offered open-ended comments, as follow:

1. It seems like a fun way to learn some of the material; in addition, rightly solving the crossword puzzle is necessary to master the subject. The word definitions must adequately summarize the meaning of the terms
2. Many times, only a small part of the crossword puzzle is related to the course material
3. It is gratifying that professors care about the experience and effective learning of their students in the classroom.
4. These activities provide an innovative way to learn
5. It would be interesting to build a bank of such games
6. The crossword puzzle solving by teams is a very good methodology because it promotes teamwork; incentives for those who first delivered the crossword puzzle are also important. More assessment is need for including as many words related to the topic as possible; creating individual crossword puzzles; solving as many puzzles as possible in the game
7. This learning methodology is very new and fun, and breaks the routine of lectures. It breaks the routine of the traditional class and is guided by the topic under discussion
8. This learning strategy complements the traditional methodology of teaching, as it encourages students to delve deeper into a subject and use their skills to meet the challenges of the game
9. The use of games is a way to make a class more competitive and dynamic. It is a good way to teach and

learn, and is a way to stop seeing learning as monotonous

DISCUSSION AND CONCLUSIONS

This paper proposed an alternative use of crossword puzzles as an educational strategy by combining both design and solution as student activities in the classroom. The results of the case study show that this strategy, as a non-traditional method is very suitable in undergraduate programs to develop skills related to handling basic conceptualization associated with a knowledge area.

Both new and more experienced students enjoyed the exercise and found it useful for their learning. Also, students' answers to the open-ended questions showed that they felt more confident in their own ability when they rightly identified answers. They were also able to cite their weak areas, while finding the exercise to be a fun learning experience. In some cases they stated that the activity was innovative, different, useful, and a fun opportunity to evaluate their own level of learning by identifying concepts that were previously unknown or unclear. It allowed them to confirm the status of their understanding and determine where they had deficiencies in their potential knowledge. These findings are consistent with the results presented by Weisskirch (2006) and Franklin *et al*. (2003).

The value of using crossword puzzles as a classroom game can be enhanced when students are given some guidelines that constrain their use of advanced technology to accomplish the task. Students must be allowed to engage in the process of manually creating the puzzle by choosing terms and creating the associated definitions in order to better understand the terms. The game is enhanced when the instructor evaluates the quality of their work and requests revisions so that the puzzles used in competition are effective.

The results are encouraging for those interested in employing a non-traditional teaching strategy for the purpose of improving learning and concept retention. This classroom activity demonstrated that designing and solving crossword puzzles can help to promote the building of vocabulary in specific topic areas. This experience has shown that students perceive improved levels of knowledge through the use of crossword puzzles as a learning aid. Based on student feedback, crossword puzzles seem to achieve a high level of acceptance as a learning tool, which is also corroborated by other authors (Crossman & Crossman, 1983; Davis *et al*., 2009).

Professors can extrapolate these findings to work in other courses and knowledge areas. This exercise is useful when teaching a significant number of new terms, phrases or theories to the students in a specific course. The crossword puzzle activity may prove to be a meaningful learning experience for building, understanding, and improving the retention of terms associated with a particular knowledge area. It also benefits students who are in the process of learning theory and makes the classroom experience more enjoyable. Instructors can rely upon the use of crossword puzzles in order to enhance student learning at the undergraduate level.

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Exhibit 1
Adapted Survey with Questions and Results from the Less Experienced Students (n=71)

Part I
Answer the following questions based upon your classroom experience <u>playing</u> the crossword-puzzle game.

	Definitely No	*Probably No*	*Neutral*	*Probably Yes*	*Definitely Yes*
Did the use of crossword puzzles enhance your learning of course terminology and vocabulary?	4	5	15	32	15

	You were playing, not learning	*You were learning*	*You were playing and learning*
During the game, you felt that:	13	12	46

	To a Great Extent	*Somewhat*	*Not at All*
Did you enjoy the use of crossword puzzles for introducing the terminology in the selected materials?	39	22	10
Do you think this type of game is suitable for the level of training you have?	19	42	10
Did you feel embarrassed or ashamed to play the crossword-puzzle with all your classmates?	2	10	59
Was the game motivating, challenging, and competitive?	42	23	6
Was team-work helpful and useful for the development of the crossword puzzles?	46	22	3
While you were playing the game, were you learning from some of the mistakes of your classmates?	43	27	1
Do you believe that some of the terms used in the crossword puzzles were outside of those used in the selected materials?	38	28	5

	Once each semester	*Once a month*	*In each class*
How often would you like to use the crossword puzzle game in the classroom?	32	38	1

Part II
Answer the next survey questions based on your classroom experience <u>designing</u> the crossword-puzzle.

	To a Great Extent	Somewhat	Not at All
Do you believe that much knowledge and creativity is needed for designing the crossword puzzles?	30	37	4
Do you believe that the production of a good crossword puzzle requires enthusiasm, dedication, and commitment?	53	17	1
Was it difficult to follow the rules when designing the crossword puzzle?	42	21	8

	0 - 5	6 - 10	11 - 15	16 or more
What do you think is the most appropriate number of terms for a crossword puzzle?	0	14	42	15

Part III
Open-Ended Question

Do you have any comments or observations to add?

Exhibit 2
Adapted Survey with Questions and Results from the More Experienced Students (n=26)

Part I
Answer the following questions based upon your classroom experience <u>playing</u> the crossword-puzzle game.

	Definitely No	*Probably No*	*Neutral*	*Probably Yes*	*Definitely Yes*
Did the use of crossword puzzles enhance your learning of course terminology and vocabulary?	0	0	1	8	17

	You were playing, not learning	*You were learning*	*You were playing and learning*
During the game, you felt that:	0	2	24

	To a Great Extent	*Somewhat*	*Not at All*
Did you enjoy the use of crossword puzzles for introducing the terminology in the selected materials?	22	4	0
Do you think this type of game is suitable for the level of training you have?	10	16	0
Did you feel embarrassed or ashamed to play the crossword-puzzle with all your classmates?	0	3	23
Was the game motivating, challenging, and competitive?	23	3	0
Was team-work helpful and useful for the development of the crossword puzzles?	23	2	1
While you were playing the game, were you learning from some of the mistakes of your classmates?	20	6	0
Do you believe that some of the terms used in the crossword puzzles were outside of those used in the selected materials?	7	13	6

	Once each semester	*Once a month*	*In each class*
How often would you like to use the crossword puzzle game in the classroom?	6	17	3

Part II
Answer the next survey questions based on your classroom experience <u>designing</u> the crossword-puzzle.

	To a Great Extent	Somewhat	Not at All
Do you believe that much knowledge and creativity is needed for designing the crossword puzzles?	5	18	3
Do you believe that the production of a good crossword puzzle requires enthusiasm, dedication, and commitment?	16	10	0
Was it difficult to follow the rules when designing the crossword puzzle?	10	12	4

	0 - 5	6 - 10	11 - 15	16 or more
What do you think is the most appropriate number of terms for a crossword puzzle?	0	6	14	6

Part III
Additional Questions for Experienced Students

	3 years or more	1-3 years	1 year or less
How long ago was your last experience with the using crossword puzzles in the classroom?	2	17	6

What other courses that you took used crossword puzzles and when?

Do you have any comments or observations to add?