Design Strategies for the Pedagogical Use of Crossword Puzzle Generation Software, In Individual and Collaborative Design Modes

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Abstract

Crossword puzzles represent a powerful pedagogical tool for both the assessment and application of knowledge attained by students in a particular discipline, such as Information Systems. Crossword puzzles may be designed for either individual or collaborative use. Participating students will find it a meaningful educational experience to answer the crossword puzzles created by other students. We shall review some of the available freeware tools for the creation of crossword puzzles, discuss some of the critical thinking skills enabled by integrating crossword puzzles into a course, and provide (based upon the experience of the authors) design strategies for the effective use of crossword puzzles (both in individual and collaborative modes) in the pedagogical environment.

Keywords: crossword puzzles, collaborative, freeware, critical thinking, educational games

1. INTRODUCTION

Crossword puzzles are generally regarded as the most popular word game in existence, and yet the crossword puzzle possesses a very short history. The first known crossword puzzle was only published in 1913, created by a journalist from Liverpool, England named Arthur Wynne, who is now regarded as the founder of crossword puzzles. His puzzle appeared in the Sunday New York World, and was called a "word-cross." This concept of a word puzzle became an immediate success, and shortly thereafter, the term "word-cross" was replaced by the more familiar "crossword" puzzle.

Today, crossword puzzles appear in numerous newspapers and magazines for the general public, and their popularity is beginning to spread from a recreational mode into a pedagogical mode. Crossword puzzles encourage logical thinking and correct spelling. Instructors and universities are finding that the crossword puzzle exercise, where the content domain is specific to a subject matter area, represents a unique way of stimulating the students' interest in recalling the desired factual information (hereafter referred to as 'clues') from a course. A typical example of this can be found at the University of Victoria Computer Assisted Language Learning facility

(http://web.uvic.ca/hcmc/), where the crossword puzzle is an integral part of a computer-aided effort to support the student in learning the vocabulary and syntax of a foreign language.

The focus on student-centered learning and hybrid learning modes make appealing educator's tools and techniques that initiate active learning. An online crossword puzzle generator enables the puzzle's use in the pedagogical process, not only at the individual level, but also around collaborative activities that deepen learning.

2. CROSSWORD PUZZLE FREEWARE

While crossword puzzles may be created by hand in a pencil and paper fashion, over the past decade a significant number of application programs have been released to aid the crossword puzzle developers in their efforts. These crossword puzzle generators will generally allow the user to enter a set of clues and answers, and will go through a heuristic algorithm to generate a resultant crossword puzzle grid. Several of these crossword puzzle generators create a web-based puzzle, enabling the user to have as output a grid in html format.

For the introduction of crossword puzzles into the pedagogical environment, it is desirable to have available software titles which are freeware, or free of charge for usage in academic institutions. (See (Kim, Scher, Turoff (2004) for a discussion and overview of freeware.) The bulk of the available off-the-shelf crossword puzzle generators are not free, and most of the titles are shareware, where the user is obligated to pay a registration fee after a specific trial period, typically 30 days. For instance, at the TUCOWS website (http://www.tucows.com) listing or Crossword Puzzle Generators (http://tinyurl.com/dvyh4), of the eleven titles presented, only one is freeware, while the others are either shareware or demo versions of commercial software titles.

The number of freeware titles devoted to crossword puzzle generation is thus limited, and so we present herein a brief overview of some of the freeware titles available to educators and students.

One of the earliest freeware crossword puzzle generators was WordJunction (Waldman, Heath, 1995), released by PC Magazine in 1995 as a 16 bit application. (Note that PC Magazine utilities are no longer considered freeware, and represent a subscription service, and thus currently "free" to only those who subscribe to the service.) Word Junction enables the user to create crossword puzzles, but makes no provision for a web-based output format.

Another popular crossword puzzle generator, available free for publicly-funded non-profit-making educational institutions, is one of six components of the Hot Potato interactive suite of word-based games, developed at the University of Victoria (http://web.uvic.ca/hrd/hotpot/). Its wizard allows the user to design both web-based and paper-based crossword puzzles, and has seen extensive use in foreign language learning environments.

Other freeware crossword puzzle generators are available, such as the Discovery Puzzle Maker (http://tinyurl.com/7z2ep). The freeware crossword puzzle generator which we recommend is Eclipse, from GreenEclipse Software (http://tinyurl.com/5csgl). Eclipse provides the user with extensive functionality in both the creation of the crossword puzzle, retrieval of clues and words, and the publishing of the crossword puzzle in various formats, including saving it in an interactive web page mode (using either a Java applet or dHTML) , or as a non-interactive web page. (A non-interactive web page implies that the crossword puzzle will need to be printed, and then the answers entered, while an interactive mode web page enables the student to enter their answers directly on the web page).

In Appendix A, we provide a short guide to the wizard like interface of Eclipse for

creating a crossword puzzle. In Appendix A, Figure 1, the user is guided through the process of creating a word list, consisting of all clues which will be displayed with the empty crossword puzzle grid. Figure 2 of Appendix A displays a portion of the resultant crossword puzzle grid, with the solution. Figure 3 in Appendix A shows the option for saving both the word list (for possible editing and modification at a future time), as well as the specific crossword puzzle which was generated. Figure 4 shows the Eclipse options for generating the crossword puzzle in either an interactive web page mode (using Javascript) or a printable mode.

3. LEARNING THEORY

In this section, we briefly present some of the cognitive foundations that are apropos to the introduction of crossword puzzles into the pedagogical environment.

Constructivist Learning Theory's focus is for the learner to construct knowledge and meaning for themselves. This student-centered learning approach initiates the active learning process in lieu of the objectivist approach used in the traditional teacher-learner classroom. Constructivists believe in developing situations for students to associate new knowledge to what is already known.

Constructivist learning emphasizes the learning process where learner thinking is initiated. The subject matter/lesson is an outcome of the process. The thinking process of the learner begins with reasoning and their own mental actions which control the learners pace. Human beings also "understand the world by constructing models of it in their minds" (Johnson-Laird 1983). Mental models provide insight into the content of the task and knowledge constructed by the individual.

Cooperative learning leverages mental models for collaboration among individuals and provides a context around the assigned task. Cooperative learning's interdependence between team members, a sense of individual accountability, interpersonal communication and group interaction provides a deeper learning experience (Johnson, 1999). As research demonstrates, small group learning produces higher achievement, and healthier and more positive relationships among students, than competitive relationships or individual experiences (Johnson, Johnson, 1991).

Bloom's taxonomy begins with knowledge and comprehension as the lowest levels of critical thinking, and advances to the higher levels of synthesis and evaluation within the course context. The associations of the taxonomy are process oriented and generally increase in complexity within the context of the course and assignment. Beginning with the individual and their own critical and reflective thinking, collaboration within the process increases the associations and deepens learning. The ability to then apply the knowledge is yet another level of the taxonomy. Overall there are six levels to Bloom's taxonomy as follows (Bloom 1984):

1. Knowledge - knowledge or mastery of subject matter.
2. Comprehension – Understand the meaning of subject matter.
3. Application – Use information in a new situation.
4. Analysis – Organize into parts and recognize hidden meanings.
5. Synthesis – Relate knowledge from old ideas to new ideas.
6. Evaluation - Compare ideas and purpose.

The importance of critical thinking for constructivist learning cannot be underestimated as a valuable tool of inquiry. It is especially important for problem-solving assignments that simulate real-world scenarios. Inquiries into past experiences and prior knowledge are sought for similar situations (Dewey 1991).

4. DESIGN FRAMEWORK FOR PEDAGOGICAL USE OF CROSSWORD PUZZLES

Crossword puzzles can be generated by an individual student, or they can be generated collaboratively by a team of students.

As noted in the prior Learning Theory section, the solution of a crossword puzzle by a student does invoke Bloom's lower level critical thinking skills of knowledge and comprehension (Mohtashami, Scher, 2000). The actual construction of a crossword puzzle, containing the selection of clues and answers, also adheres to a constructivist type model.

Our recommended strategy for crossword puzzle generation is a four-phase approach, as follows:

Phase I - EXAMPLE: Instructor designs a sample crossword puzzle, created using the same crossword puzzle generation software package that the students in the class will use. This crossword puzzle will be "published" in the computer mediated communication system (CMC) being used in the class environment, and available for all students in the class to view. A typical CMC could be Webboard, WebCT, Blackboard, etc. The "domain" of the crossword puzzle clues could be some topic in the course, or it could even be dealing with the functionality of the CMC being used in the class (which would be useful for students who are neophytes in using a CMC).

Phase II - CREATE: Using either the individual or collaborative mode, as specified by the instructor, students will create a crossword puzzle using the assigned course content domain. The crossword puzzle grid, together with the clues will be posted to the CMC, while the solutions will be emailed to the instructor.

PHASE III - SUBMIT: Each student will be assigned to complete one of the posted crossword puzzles. The completed crossword puzzle will be submitted to the instructor, who will compare the student's solution with the specified answers, and provide the grade to the student. (An alternative would be to have the submission graded by the student or team who created the puzzle).

PHASE IV - SHARE: The instructor will make available to all students, via the CMC, the crossword puzzle grids, clues and solutions, of all submissions. The presentation of all the crossword puzzles provides an excellent learning tool for the course content, and serves as a challenging review for students in studying for examinations.

In Table 1 below, we provide a tabular framework which compares and contrasts the phases in the Design Process Model, for the Individual and Collaborative Design modes. It should be noted that the substantial change takes place in the CREATE phase, where the Collaborative Design mode utilizes a team collaborative process to generate the clues and answers, based upon discussion of individual team member's submissions. Students in the Individual Design mode do generate substantially more clues and answers, but these are not reviewed and discussed.

Table 1. Crossword Puzzle Usage – Four Phase Process Model

Phase	Individual Crossword Puzzle Design Mode	Collaborative Crossword Puzzle Design Mode
I EXAMPLE	Instructor designs a sample crossword puzzle, created using the same crossword puzzle generation software package that the students in the class will use. This crossword puzzle will be "published" in the (CMC) being used in the class environment, and available for all students in the class to view.	Instructor designs a sample crossword puzzle, created using the same crossword puzzle generation software package that the students in the class will use. This crossword puzzle will be "published" in the (CMC) being used in the class environment, and available for all students in the class to view.
II CREATE	Individually, each student designs his/her own crossword puzzle with clues from an assigned content domain.	A. Individually, each student from each team creates an assigned number of clues towards a team crossword puzzle from an assigned content domain. B. The team works together to consolidate all contributions and eliminate any redundant clues.
III SUBMIT	Individually, each student will be assigned to complete one of the posted crossword puzzles. The completed crossword puzzle will be submitted to the instructor, who will compare the student's solution with the specified answers, and provide the grade to the student.	Collaboratively, each team will be assigned to complete one of the posted crossword puzzles. The completed crossword puzzle will be submitted to the instructor, who will compare the team's solution with the specified answers, and provide the grade to the team.
IV SHARE	The instructor will make available to all students, via the CMC, the crossword puzzle grids, clues and solutions, of all submissions	The instructor will make available to all teams, via the CMC, the crossword puzzle grids, clues and solutions, of all submissions.

5. INDIVIDUAL CROSSWORD PUZZLE GENERATION – DESIGN STRATEGIES

In this section, we discuss the actual application of the individual generation of crossword puzzles to an undergraduate Database Design course, while the following section discusses an actual application of the collaborative generation of crossword puzzles.

Phase I - EXAMPLE: Instructor posts a crossword puzzle, using as a content domain some of the fundamental definitions of database design, and based upon the initial chapter of the course textbook. The crossword puzzle is created with the Eclipse crossword puzzle generator, and the instructor provides detailed instructions for using Eclipse and downloading the freeware application. This provides students with both the necessary guidance, as well as an example of the desired end-product of the assignment. The puzzle grid, with clues (but no answers) will be in html format.

Phase II- CREATE: Using the Eclipse Crossword Puzzle Generator, each student, given an assigned Database Design content domain, will create a crossword puzzle using material from this content domain, consisting of between 25 and 30 clues. The crossword puzzle grid, together with the clues, will be posted to a group communication space (Webboard), while the solutions will be emailed to the instructor.

Phase III - SUBMIT: Each student will be assigned to complete the crossword puzzle created by another student in the class. The completed crossword puzzle will be emailed to the instructor, who will compare the student's solution with the specified answers, and provide the grade to the student.

Phase IV – SHARE: After all students have completed Phase III, the instructor will synthesize all the student puzzles, and their solutions, into a single PDF file, and post this PDF file in the class Webboard for student sharing.

Our experience has been that the output of Phase IV, a set of N crossword puzzles with clues and answers (where N is the number of students in the class completing the crossword puzzles), provides an outstanding learning tool for learning database concepts, and serves as a challenging review for students in studying for midterm and final examinations Moreover, students find the process of creating clues and answers for the crossword puzzle to be an educationally rewarding one, requiring each student to carefully review the content domain, and meticulously construct clues which are characterized by succinctness and clarity.

6. COLLABORATIVE CROSSWORD PUZZLE GENERATION – DESIGN STRATEGIES

Newly formed collaborative teams using computer-mediated communications often struggle with getting started. Two common problems are trust and the readiness to participate in the task. Establishing trust in early team formation serves as a stepping stone to engage the team and is vital for team success. "Swift trust" is a demonstrated technique developed by Meyerson et al. (1996) for temporary teams who form around a clear purpose, with a common task and a finite life span. As Meyerson mentions, several social characteristics accompany swift trust and include: vulnerability to entrust others good will; uncertainty to suspend doubt to execute the task performance; the willingness to take risks; and the expectation that benefits will be realized through the temporary group activity (Coppola, Hiltz, Rotter, 2004).

Readiness to participate in the task in a CMC environment encompasses both readiness of the task and readiness of the technology. The behavioral intention of the student is often influenced by the clarity of the task in relation to the understanding of the team. The readiness and acceptance of the CMC technology can also influence behavioral intention. Collaborative crossword puzzle generation is suggested as a vehicle to address both trust and readiness through a two-step scaffolding process.

Our recommended strategy for collaborative crossword puzzle generation follows the four-phase process model, as follows:

Phase I - EXAMPLE: Instructor posts a crossword puzzle, created with the Eclipse Crossword Puzzle Generator, along with detailed instructions for using Eclipse and downloading the freeware application. The crossword puzzle to be completed by the students serves as a mental model for the collaboration tasks. The mental model is achieved by having students complete an online crossword puzzle individually before working as a team. The additional benefit of the students completing a crossword beforehand is to establish readiness for the task or technology.

In our case, we chose clues about the functionality of the WebCT discussion board used. Students' exposure to WebCT varies in the class, from extremely minimal to experienced, and represents the reason our example crossword puzzle was focused on the CMC technology, rather than the

material in the syllabus (as was the case with the Database Design course.)

The clues themselves are geared towards all levels of experience and encourage the students to navigate through the WebCT discussion board to complete the crossword. A few of the clues cannot be completed without reviewing the functionality of the WebCT discussion board. The objective of these statements is to provide a common background for all students using the WebCT discussion board.

The expected outcome is to minimize the difficulty in locating common functions within the WebCT discussion board that hinder team cohesion and impact trust early in a collaborative effort.

Phase II - CREATE: The collaborative crossword puzzle process begins with an individual task to initiate readiness and critical thinking. Each student provides four clues and emails the instructor within the WebCT discussion board. The instructor will post all clues in the team discussion area for use by the team. We suggest the first team deliverable should be two clues that are of particular interest to the student in relation to the assigned reading materials. The other two clues are to reflect information that is either confusing or of difficulty to the student from the same reading materials. This ensures creativity and reinforces critical thinking.

After all students submit their clues, students are assigned randomly to a team and all student contributions are posted in the team conference so discussions can begin. The teams are to construct a collaborative crossword puzzle based on all student contributions, minus three statements. This generates discussion among the students by creating a need to group and compare like statements for the elimination process (refer to table 2 Phase II B). The discussions are normally a combination of asynchronous discussion board postings and synchronous chats. (Teams may also use the telephone to communicate).

Once the chosen statements are identified, one team member will generate the crossword puzzle using the Eclipse crossword software.

Phase III - SUBMIT: Each team will be assigned to complete a crossword puzzle created by another team in the class. The completed crossword puzzle will be emailed to the instructor, who will compare the team's solution with the specified answers, and provide the grade to the team.

Phase IV - SHARE: The instructor requires that all student teams post their crossword puzzles and answers in the class discussion board, so that all students can share in the learning of course concepts.

A cross-reference that compares Bloom's taxonomy for both the individual crossword puzzle mode and collaborative crossword mode is presented in Table 2 below.

Table 2. Leveraging Bloom's Taxonomy for Crossword Puzzle Generation

Bloom's Taxonomy		Crossword Puzzle Generation	
Competence	**Skill Demonstrated**	**Individual Crossword**	**Collaborative Crossword**
1. Knowledge	• Knowledge of the subject matter • List, define, examine or describe	• Solve the instructor's crossword puzzle individually to demonstrate knowledge of class materials or the context of the course	• Solve the instructor's crossword puzzle individually to demonstrate knowledge of class materials or the context of the course
2. Comprehension	• Understand meaning of subject matter • Interpret and associate	• Interpret and associate the clues with the assigned class materials	• Interpret and associate the clues with the assigned class materials
3. Application	• Use information in a new situation • Solve problems using required skill • Apply, illustrate or relate	• Generate a crossword puzzle using the course content domain to illustrate knowledge of class materials	• List and define clues and answers to contribute for the collaborative crossword to illustrate knowledge of the course content domain
4. Analysis	• Organize into parts • Recognize hidden meanings • Analyze, order, classify	• List and define words for the crossword generation • Interpret the clues to use	• Organize and order contributions from team mates • Analyze, classify and consolidate team mates clues
5. Synthesis	• Relate knowledge from old ideas to new ideas • Combine, modify, create	Complete another classmates crossword individually (synthesis of the instructor crossword and classmate's crossword)	• Consensus on clues to select • Generate a collaborative crossword puzzle (synthesis to both instructor crossword and team mates clues)
6. Evaluation	• Compare ideas and purpose • Assess value of ideas • Assess, rank, measure	Compare the individually generated crossword puzzles (clues and answers) to the submitted crossword puzzles of others	• Compare the collaboratively generated crossword puzzles (clues and answers) to the submitted crossword puzzles of others

Adapted from Benjamin S. Bloom Taxonomy of Educational Objectives (1984).

For example, in our graduate level information systems principles course, students completed an instructor generated crossword puzzle. The crossword puzzle clues center-around WebCT discussion board concepts at the start of the semester. These clues require the student to navigate through the WebCT discussion board features to solve the crossword puzzle. Moreover, the students

are introduced to the online Eclipse Crossword Puzzle that will be used for generating their team crossword puzzle in Phase II. In Phase II, the student contributes four clues toward the team crossword puzzle and in Phase III, students collaborate to generate the team crossword puzzle Phase IV provides an overall class review of all answers.

7. SUMMARY AND CONCLUSIONS

We have provided in this paper several strategies for the incorporation of crossword puzzles into the pedagogical delivery of course content. Such assignments will actively involve the student in the learning process, and represent an interesting way for students to master the assigned course material. Crossword puzzles as a pedagogical tool do provide an important option in the repertoire of tools the instructor has to creatively inject a new level of interest in the course material, but, of course, the effectiveness of crossword puzzles does need to be evaluated by measurement instruments, to enhance our understanding of the most appropriate means for integration into the pedagogical delivery of an instructor.

Our research provides both a usage for the crossword puzzle in an individual application and as a strategy towards building swift trust in virtual teams in an online environment where active learning is a challenge. Most courses in Computing Sciences which have a significant knowledge base of factual content and definitions would be obvious beneficiaries of a pedagogy which included individual mode, or collaborative mode, crossword puzzles. The authors have successfully utilized crossword puzzles in regular face-to-face classes, as well as Hybrid Learning and Distance Learning sections. We have integrated the Crossword Puzzle into courses as diverse as Database System Design and Management, Systems Simulation and Information Systems Principles.

Future research should include outcome assessment to validate the learning outcome. Assessment should be conducted at both the individual and peer level to measure perceived learning outcome and individual behavior both of the individual and the individual as he/she interacts within the team.

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APPENDIX A
LIST OF FIGURES

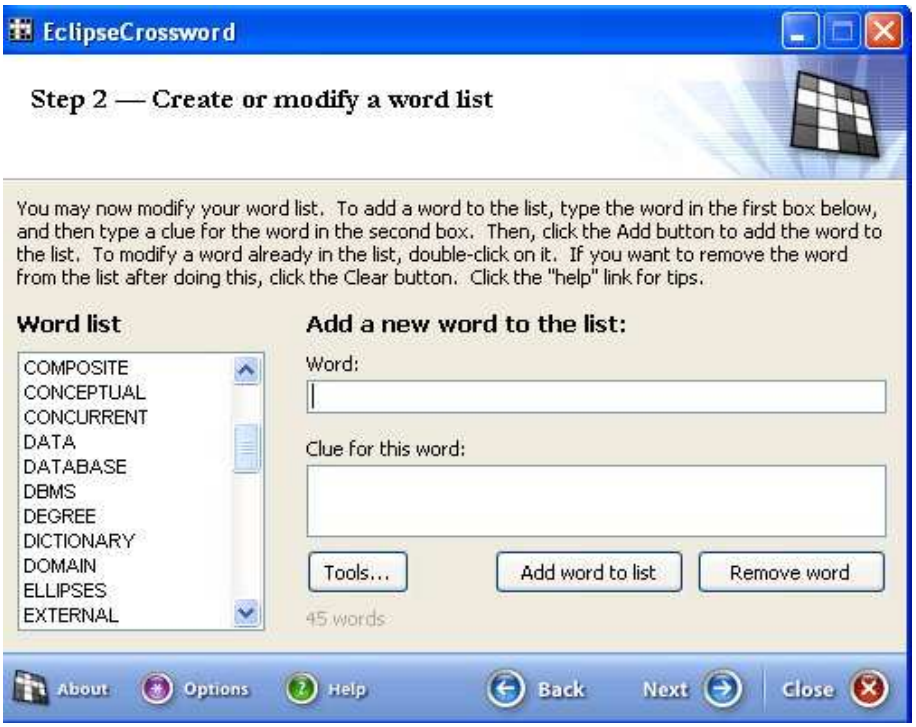

Figure 1. Creating a word-list for a Database Design Course, Using the Eclipse Crossword Puzzle Generator

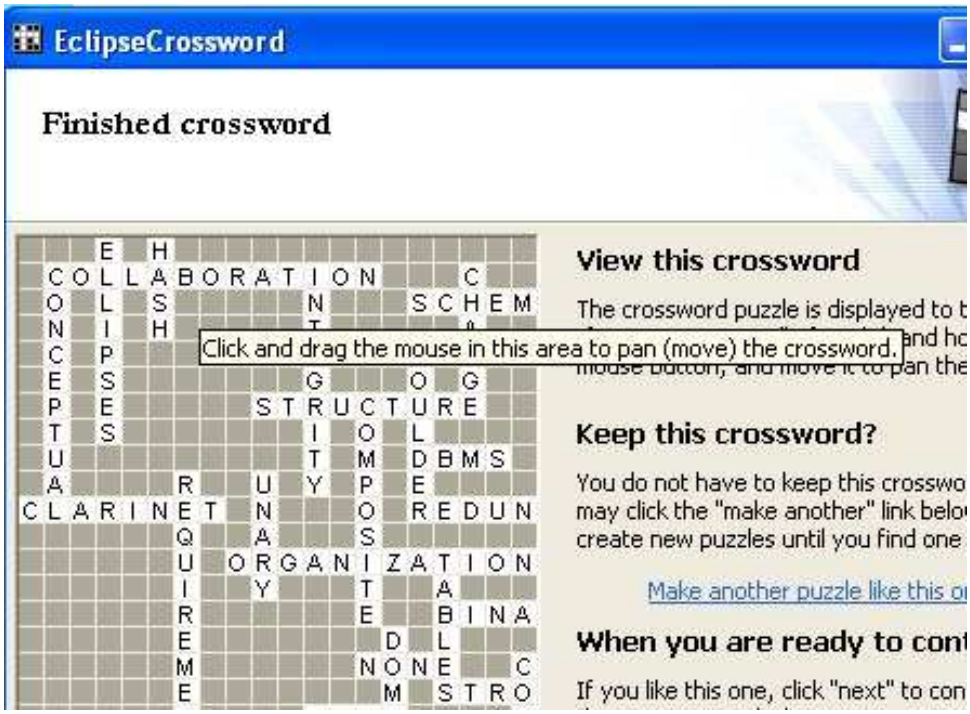

Figure 2. Snapshot of Part of the Eclipse Generated Crossword Puzzle

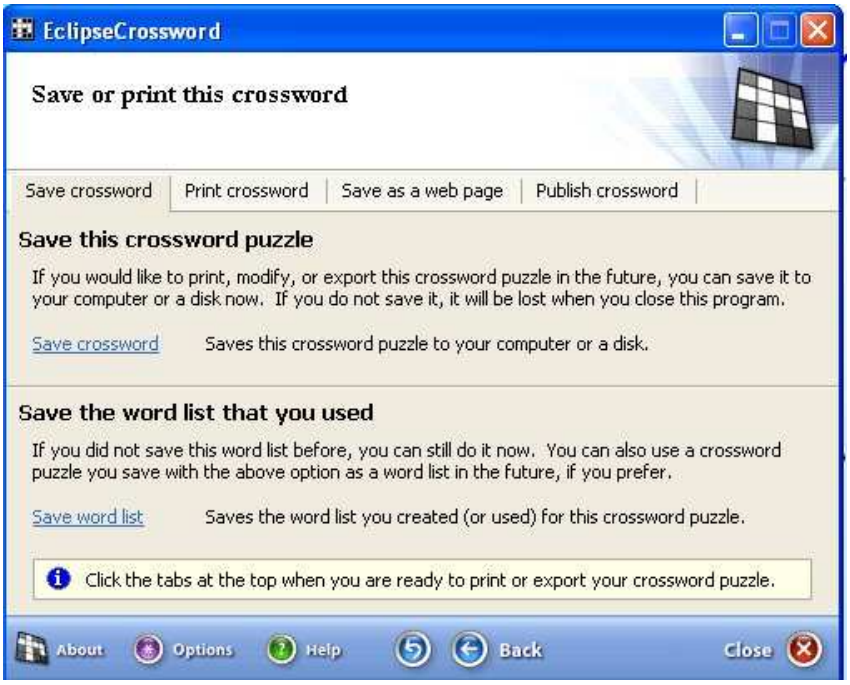

Figure 3. Saving the Crossword Puzzle and Word List in Eclipse

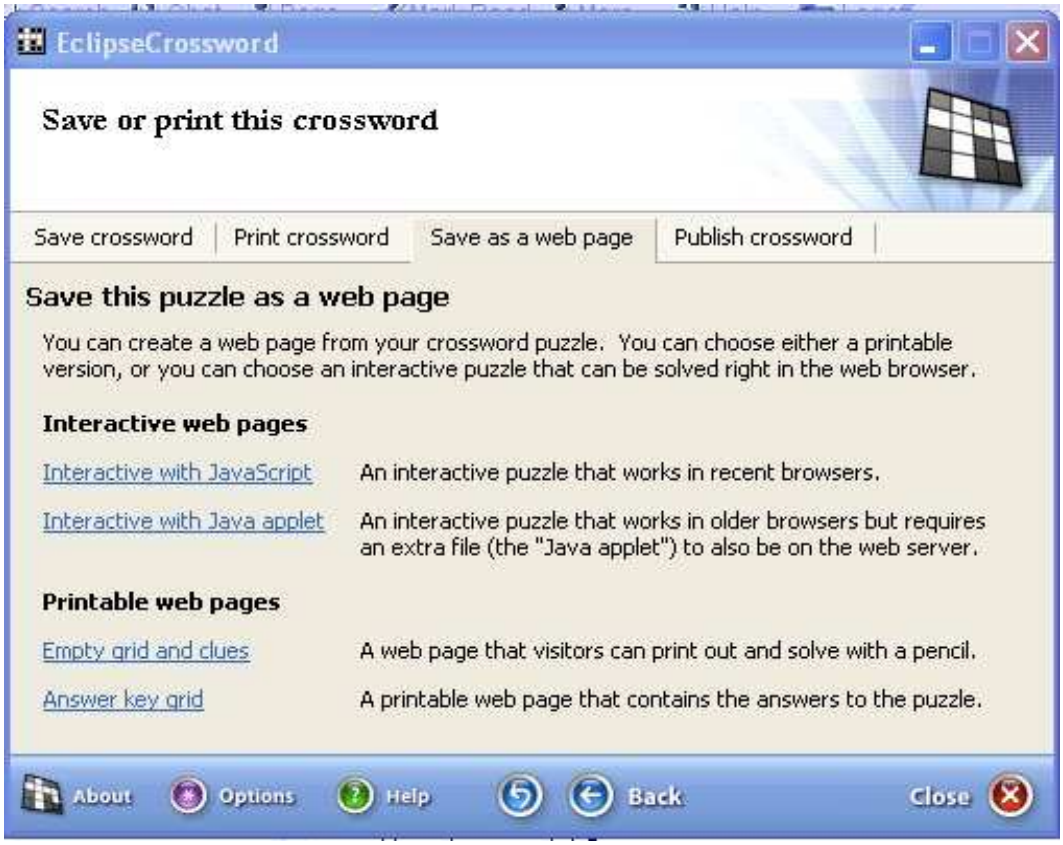

Figure 4: Options for Publishing and Printing the Crossword Puzzle in Eclipse