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The Development of Thai EFL Secondary School Students' English Science Vocabulary Knowledge through Science Vocabulary Crossword Puzzle (SVCP) Practices: Action Research

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Abstract
Vocabulary plays an important role in the Content-Based classroom, making EFL Students' science vocabulary knowledge critical to their content understanding. The purpose of this action research was to enhance students' science vocabulary knowledge of 9thgrade students through science vocabulary crossword puzzle (SVCP) practices. The research group comprised 33 students of a science classroom using English as the medium of instruction in their second semester of the 2020 academic year at a large secondary school in Bangkok. The action research cyclical process of Kemmisand McTaggart (1981) was adopted through the steps of (1) Plan, (2) Act, (3) Observe and (4) Reflect. The innovation being introduced was a collection of science vocabulary crossword puzzle materials. The research instruments used were the science vocabulary knowledge test and the students' opinion questionnaire towards SVCP practices. The assessment of students' vocabulary knowledge was conducted before and after the delivery of crossword puzzle practices. The data was analyzed by a dependent sample t-test. The research findings were as follows: (1) After implementing SVCP practices, the mean of students' science vocabulary knowledge score had increased by a statistically significant 0.05.and(2) students had positive opinions toward the SVCP practices.
Keywords: Science vocabulary knowledge, Crossword puzzle, Action Research, Content-based instruction

Introduction

Vocabulary learning plays a fundamental role in second language learning and teaching because a limited vocabulary in a second language hinders all four listening, speaking, reading, and writing (Alqahtani, 2015). For L2 learners, knowledge of vocabulary is the central tool for the effective acquisition of the target language (Nation, 2005). Students need to have adequate vocabulary knowledge to develop listening, speaking, reading, and writing skills (Richards, 2015). They cannot express their ideas and thoughts if they do not have sufficient vocabulary. Schmitt (2008) emphasized that learners need knowledge of a sufficient number of vocabulary words, terms, and phrases to succeed in language learning. The larger the vocabulary of the learners, the more effectively they listen, speak, read and write in the target language. Therefore, vocabulary learning and vocabulary teaching is the most important part of a lesson in an L2 classroom. In the content-based classroom, ignorance of some of the content vocabulary may obstruct the student's learning; this can affect especially their understanding of reading text and listening to the teacher's explanation.

Hence content vocabulary knowledge, such as science vocabulary, can be considered the moderating variable for other skills, such as a student's reading, writing, and cognition.

However, learning vocabulary is more difficult in a second language than in the learner's first language (Esteve, 2016). The difficulty is compounded when the vocabulary is discipline specific because new learning must build upon the size and depth of the learner's existing vocabulary and ability to use their schemata, prior knowledge to connect to the new vocabulary being introduced. Saengpakdeejit (2014) reported that the main problem for Thai students to learn English well is the lack of vocabulary knowledge. The EFL students in the school context where this study was conducted have been exposed to English as a fundamental course from both Thai and foreign teachers. They spent a great deal of time learning the new words from teachers' direct translations or dictionaries, but did not significantly practice English on their own. In addition to science, the students also study mathematics in English. There are many chances to encounter technical terms and subject-content vocabulary. Consequently, students are prone to forget the new words easily, especially if they are not used frequently, or to know rigidly the definition and translation of the words, but fail to develop a more integrated and inclusive vocabulary knowledge.

Teaching vocabulary using a game is one of the many ways to make the learning process more effective and interesting. Jaramillo et al., (2012) states that 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 offers a challenge that will motivate the students to fulfill the puzzle (Widaningsih, 2009). Crossword puzzles can be used in the teaching learning process to increase the students' interest, to motivate students in learning English, and then the students may feel more relax. It has been beneficially used in the teaching learning process. It gives many opportunities for the students to spell and pronounce the vocabulary. The students will feel entertained, appropriately challenged, and generally relaxed; they will memorize the vocabulary in a different way, that is, by rewriting the words or terms. In the science classroom, there are many content-related vocabularies that students should recognize during the lesson for them to understand the content efficiently within a time limit of a class period; therefore, the practice of using a crossword puzzle activity is an effective strategy. The purpose of this study, therefore, was to propose a way to apply crossword puzzle practice to vocabulary teaching and investigate to what extent 9th-grade students' vocabulary knowledge could be improved in a Thai public school.

Statement of Problem

The researcher has found that students demonstrate difficulties learning science vocabulary, especially when studying within content-based instruction settings. The researcher would like to find some practices or exercises that help students to recognize science vocabulary and that enhance their motivation in learning English. In response to the preliminary survey study, science teachers were asked to give their opinion about students' vocabulary knowledge. A "vocabulary self-awareness chart" (Grant & Fisher, 2010) was used to gather information about students' vocabulary knowledge. It is confirmed that students encounter difficulties with recognizing science vocabulary. The researcher tried to find the proposed practice or suggested activities to improve students' vocabulary knowledge. Several studies including, Santos et al., 2019; Lestari and Yulia, 2018; Amiri and Salehi, 2017; Nugroho, 2017, have used the crossword puzzle to enhance student's vocabulary knowledge or spelling skills in English classes. However, no study was conducted on using the crossword to improve student's learning in the science classroom, except research by Agarwal et al., (2020) on graduate student learning of forensic medicine vocabulary using crossword puzzles. There remains the question of whether a crossword puzzle activity can be used in a science content-based classroom for lower secondary students. Hence, the recent research was conducted to improve 9th-grade students' science vocabulary knowledge adopting the action research cycle.

Research Purpose

To investigate the improvement of science

vocabulary knowledge of 9th grade learners after using crossword puzzle practices and the opinion of students toward crossword puzzle activities.

Research Questions

1. To what extent does Science Vocabulary Crossword Puzzle (SVCP) practices improve science vocabulary knowledge of 9th grade students?
2. What are the students' opinions toward Science Vocabulary Crossword Puzzle (SVCP) practice on science vocabulary knowledge?

Methodology

Research Design

The research adopted the model of action research planner proposed by Kemmis and McTaggart (1981), a cyclical process consisted of the plan, act, observe and reflect. During the "Act" phase one-group pretest-posttest design was adopted in implementing the innovation, Science Vocabulary Crossword Puzzle (SVCP), and collecting both numerical and descriptive data from the participants. The study was conducted for nine weeks in the second semester of the 2020 academic year. The science vocabulary follows the main content of space science, including (1) Fundamental concepts of astronomy, (2) solar system, stars, and galaxies, (3) the relationship between Sun-Earth-Moon, and (4) space technology and exploration. The participant group consists of thirty-three9thgrade students of a school in Bangkok, selected using purposive sampling. Considering the action research paradigm, the study does not attempt to claim the generalizability of the results to the wider population but rather focus on transferability in similar contexts.

Development of an Innovation (Science Vocabulary Crossword Puzzle)

In developing the innovation, the researcher prepares the innovation, which comprises the SVCP materials, following four development steps. The first step, content analysis, involved reviewing the space science content and related vocabulary listed in the textbook's lesson plans shown in Table 1. As there were four units taught over seven weeks of implementation, the researcher planned to provide the crossword worksheet practices once each week, allowing the students seven opportunities to use the SVCP activity. In the second step, all vocabulary items in each unit were separately input into crossword creation software that is available at no cost on the internet at https://worksheets.theteacherscorner.net/make-your-own/crossword/. After the crossword grids were created, the third step was to write clues such as definitions or examples. To facilitate students' use of the SVCP, some letters were pre-filled in the grids to help guide students through the practice. The fourth step was the final check of the resulting SVCP collection. The grids, clues, and answers were carefully reviewed to avoid likely confusion or misunderstanding of the vocabulary. As a final part of this step, three teachers (two of science and one of English) were asked to validate all the seven crossword puzzle worksheets.

Table 1: Science Concepts (Content) and Examples of Target Science Vocabulary

	Content	Vocabulary
1	fundamental concepts	astronomy, astrology, space, universe, galaxy
2	solar system, stars and galaxies	planets, mercury, Venus, mars, Jupiter, asteroids, meteoroids, meteorite, crater, comets, corona, sunspots, solar wind, aurora, constellation, zodiac, Polaris, nebular, spiral, elliptical
3	the relationship between sun-earth-moon	rotation, revolve, hemisphere, solstice, moon phases, gibbous moon, crescent, eclipses, tides, zenith
4	space technology and exploration	satellite, telescope, Skylab, space shuttle, gravity

Innovation Plan

The researcher planned to implement the SVCP practice for seven weeks. Regarding the procedures of presenting crossword puzzles by Lee (1963), the researcher decided to follow the first procedure: the teacher gives the same crossword to each student. The students attempt to solve the puzzle individually based on the included clues. There are two reasons for selecting this procedure: (a) student lack of

familiarity with the activity and (b) classroom time constraints. This was the first time the students tried the activity, so they might not have been familiar with the innovation. The class schedule comprised only seven weeks for this science content class. The focus was on the lesson content. Little time was available to practice language skills. Hence, the simplest procedure was considered most suitable.

Nonetheless, the researcher planned 5-10 minutes for students to complete the crossword puzzles after learning the science concept of the particular class. In total, the students had seven weeks to practice the SVCP. The pretest and post-test were administered before and after the implementation.

Characteristics of Educational Innovation (Science Vocabulary Crossword Puzzle)

The researcher based the characteristics of SVCP on the four aspects of education innovation proposed by De Lano, et al., (1994): change, development, novelty, and improvement. The change relates to the methods of science vocabulary instruction because it emphasized students' vocabulary knowledge in a science classroom. Development was found in the evidence of the acceptability by students of SVCP as a tool to promote vocabulary learning and in the positive change in students' opinions towards the innovative activity. In terms of novelty, the use of crossword puzzles is not particularly new in the EFL classroom context, though it is new in the content-based science classroom. Finally, improvement was evident in the improved learning results supported by SVCP, particularly addressing students' difficulty in recognizing and developing a science vocabulary. The research could therefore inform other specific content-based instruction.

Literature Review of the Innovation

The SVCP was developed based on the review of related literature and research studies, including some existing principles and studies that were instructive.

Vocabulary Knowledge

There are two types of vocabulary knowledge: receptive and productive. Receptive vocabulary is the set of words that are recognized and understood. Students use these vocabularies when listening and reading. This is also identified as "passive vocabulary". Productive vocabulary is words that the students should be using in their speech and writing. This category is often called "active vocabulary". Nation (2013) argues that when considering vocabulary knowledge, two questions should be asked: what is a word? and what is involved in learning a word? He proposed three components of vocabulary knowledge, including form, meaning, and use. Additionally, Beck, Mckeown, and Kucan (2002) identify five points on a continuum of vocabulary knowledge, ranging from (1) no knowledge to (2) general sense and positive or negative connotation to (3) narrow (context-bound knowledge) to (4) having knowledge of a word but not being able to recall it readily and therefore use it appropriately in situations, to (5) rich, decontextualized knowledge of word's meaning, its relationship to other words, and its extension to metaphorical uses.

Vocabulary Instruction

Nation (2005) identifies three processes necessary for thorough acquisition of new vocabulary (1) noticing, (2) retrieval, and (3) generative use. Schmitt (2000) argued that there are two types of vocabulary instruction. The first one is explicit vocabulary instruction; it directly focuses on the words to be learned. The activities make learners notice new vocabulary by explaining directly definition, highlighting target words in the passage, doing cloze exercises, memorizing words from flashcards, using or playing games to remember word meaning (Webb & Nation, 2017). The second type is implicit vocabulary instruction: learning vocabulary without focusing on any particular word, that is, learning that is a by-product of engaging in other activities such as reading and listening (Brown, 2015). The learning goal emphasizes comprehension or communication rather than learning new words in particular (Paribakht & Wesche, 1999).

The Importance of Content or Academic Vocabulary in a Content-based classroom

Considering the content-based classroom, Cummins (1980) identifies two communication skills: BICS and CALP. BICS (basic interpersonal communication skills) refers to language necessary for everyday conversation that is not cognitively

demanding. In another word, BICS is a language that students use in informal contexts such as in the cafeteria or outside of school with peers and at home with family members. On the other hand, CALP (cognitive academic language proficiency) refers to language necessary for academic and formal settings, which is cognitively demanding. CALP is the language students use in a classroom setting for learning and therefore shows relevance to the content-based classroom since students need to be equipped with an academic language or CALP to achieve in these subjects. It is important for content teachers to balance the use of BICS and CALP. If the language is too cognitively demanding, learning cannot take place. On the other hand, if the language is too simple and non-specific, learning the requisite content vocabulary is limited. Increasing students' CALP knowledge is the desired outcome.

Crossword Puzzle in Enhancing Vocabulary Learning

Wahyuningsih (2009) defined the crossword puzzle as a game in which words are guessed from their definitions, examples or clues, and then entered into the appropriate empty squares on a diagram of white and black squares. The crossword has words written horizontally and vertically. Correctly decoding a crossword requires correct spelling. Puspita and Sabiqoh (2016) stated that the crossword puzzle is an effective teaching tool of terminology, definition, spelling, and pairing key concepts with related names, resulting in greater retention and memorization of facts. By its nature, the successful completion of a crossword puzzle involves establishing a link between the meaning expressed in a clue and a corresponding form in the answer grid. It is a paradigm example of a productive meaning-to-form retrieval activity.

Lee (1963) proposed five procedures of presenting crossword puzzles in classroom. (1) The teacher gives the same crossword to each student. (2) Students individually solve the puzzle with the help of written clues. (3) The teacher divides the class into groups, giving each group a different crossword and instructing each group of students to solve the puzzle collectively. (4) The teacher gives the crossword puzzle to every student to attempt to solve individually and later divides the class into groups in which students can share their answers to complete the puzzle collectively. (5) The teacher writes crosswords on the board and provides clues orally, solving the crossword step-by-step with the entire class. The class is then divided into groups, and each group comes to the board and fills in the missing words. Using the crossword puzzle activity in teaching vocabulary is one of the alternative techniques to help students construct and improve their vocabulary mastery. Moreover, the crossword puzzle can be one of the activities in practicing vocabulary which can help the students recognize and become more familiar with the words and manipulate and remembering the words (Scrivener, 2005).

Research Settings and Participants

The setting chosen for this study was a public school in Bangkok. The participants were enrolled in a Basic Science III course in the 2020 academic year. They were arranged in one class with different English proficiency. Students are familiar with using English as a medium of instruction since they have been enrolled in this program for three years.

Research Instruments

Two research instruments were used:

1. Science vocabulary knowledge pretest and post-test designed to measure the students' vocabulary knowledge learned from the SVCP practices. There were two parts: part A, comprised of matching words to their definitions, and part B, comprised of ten items to test translation of the vocabulary.
2. The students' opinion questionnaire consisted of two parts; the first part consisted of seven questions for the students to rate their degree of agreement on a Likert scale where 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree. The second part consisted of one optional open-ended question intended to elicit students' opinions towards using SVCP practice in the classroom.

Data Collection Procedure

The researcher instructed the lessons and collected the data himself. The Action Research

Cycle proposed by Kemmis and McTaggart (1981) was adopted, as shown in Figure 1. Because of time limitations, only one cycle was conducted in this research. The continued cycle will be conducted until the problem is solved. Figure 2 shows the implementation plan of the innovation SVCP in this research study.

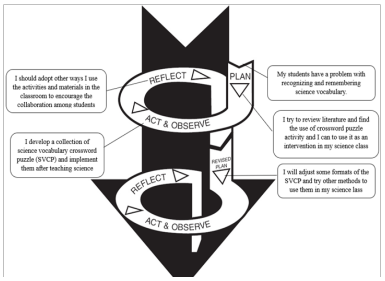

Figure 1:The Action Research Planner (Kemmis and Mc, 1981)

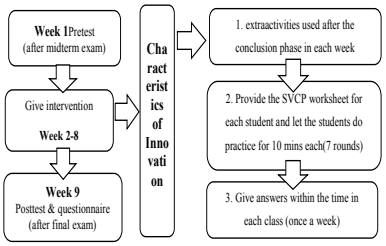

Figure 2: Implementation plan of the innovation (SVCP)

Data Analysis

The information obtained from the study was analyzed following the research questions.

1. Data analysis for research question 1 concerning the effectiveness of the SVCP practice on EFL students' science vocabulary knowledge. To analyze the data, participants' means scores from pretest and posttest will be collected. The statistics of science vocabulary knowledge score SVCP practice were presented by Mean, Standard Deviation (SD), and one-sample t-test.
2. Data analysis for research question 2 addressing students' opinions towards the use of SVCP practice in the classroom. The questionnaire data will be analyzed by the frequency of the students' answers and then presented in the comparative bar chart including each item. Some information from the open-ended section is also provided in the Results section of this article.

Ethical Considerations

In this research, the researcher explained to students and parents in detail the purpose and method of research. Students and their parents who participated in the study signed a consent form to participate in the study with both notice and willingness. Students' personal information, such as name, face, and school,was encoded to ensure anonymity. All information obtained was provided voluntarily, and students were free to leave the research project at any time. Thus, the information obtained truly reflects the understanding and ability of the students.

Results

Students' science vocabulary knowledge scores after the implementation of SVCP are higher than before the lessons at a statistically significant level of 0.05. (as shown in table 3)

Table 3: The Comparisons of Students' Science Vocabulary Knowledge Pretest and Posttest Scores Calculated by Dependent T-Test of Target Group (n=33)

Full Scores	Statistics					
	Pretest			Posttest		
	$\bar{X}$	$\bar{X}$ Percent	SD	$\bar{X}$	$\bar{X}$ Percent	SD
30	8.67	28.9	3.31	23.75	79.16	2.83

Students' opinion toward the use of SVCP practice in the classroom, as shown in Figure 3. All results were rated "strongly agree," meaning students' opinions toward the use of SVCP are "positive." Some comments from the open-ended section are provided to support the numerical data.

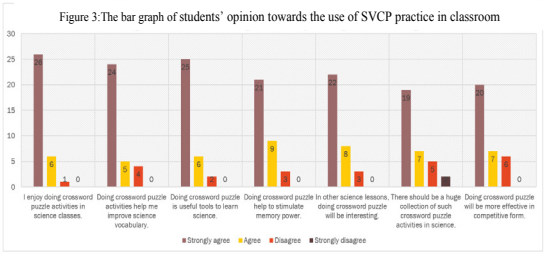

Figure 3:The bar graph of students' opinions towards the use of SVCP practice in the classroom

Sample answers to the open-ended opinion questions follow.

1. What do you think about learning science vocabulary through crossword puzzle activities?

Student A: "I think learning vocabulary in this way allows us to learn science vocabulary easier. It is a word that we have never seen or known before and can be enjoyed simultaneously. There are no long texts to read. This is not stressful. It is like a game to get knowledge and make us interested and want to learn more. In short, I am very impressed learning in this way."

Student B: "Doing this activity can be both fun and educational at the same time, and without a headache, because we just find the right words to fill in the blank grids. It makes us interested and wants to do this activity again in the next semester."

2. In your opinion, what are some limitations of using crossword puzzles to learn science vocabulary?

Student C: The limitation is that people who are not good at the language may be boring. Because they can't interpret it out. They may have less knowledge and enjoy than a person who is fluent in a language.

Student D: Difficulty in connecting vocabulary and science content.

Discussion

The findings of this study highlight the positive results of vocabulary teaching using crossword puzzle practice in improving students' science vocabulary knowledge. The posttest scores revealed that the students' science vocabulary knowledge had increased after the delivery of SVCP practices. This is due to the fact that the practice gives students the chance to exercise their vocabulary again after learning from the class. Students try to match the definition or the meaning with science vocabulary as Richard (2015) stated that the drilling vocabulary is good for repetition and memorization. The study has confirmed that the crossword puzzle can be used in the content-based classroom for secondary levels and enhance students' vocabulary knowledge.

Additionally, the practice can offer a challenge that will motivate the students to try to complete the puzzle (Widaningsih, 2009). However, based on the responses to the open-ended questions, students still think that the practice can only help them memorize or simply recognize the vocabulary, that is, rote learning. They find it difficult to link between the science content and vocabulary learning. The students cannot have science vocabulary knowledge in terms of the meaning aspect because the background knowledge plays such an important role. Consistent with the thoughts proposed by Priebe, Keenan & Miller (2010), the student's prior knowledge appears to lead them to more accurate and faster vocabulary knowledge identification. In addition, prior knowledge also affects students' motivation (Perkins & Salomon, 2012. Students' prior knowledge about vocabulary can be leveraged to help students build up the desire to learn more. Therefore, teachers can enhance students' motivation to learn vocabulary knowledge by creating opportunities for the students to activate and connect their prior knowledge to the lessons. According to Bhakti &Marwanto(2018), students' positive emotions improve their vocabulary learning effectiveness because vocabulary-learning experiences associated with positive emotions are more easily stored and recalled.

Limitation of the Study

Some limitations should be taken into consideration. Enough time should be allocated for students to complete the crossword(s). Science classes are already full of content knowledge, making it very challenging for a teacher to carefully plan the balancing of content and students' language skills. Types of clues should be varied, such as pictures of the target vocabulary, to help scaffolding students. Regarding the validity and reliability of the research, the science vocabulary test should be

designed carefully and in parallel. Additionally, the use of more qualitative methods such as interviews, observation, and teacher reflective journals to help gather more in-depth data and triangulate the results.

Implications

They are considering practical contribution. The studied SVCP helps improve students' science vocabulary knowledge to recognize the written word forms and spelling, a necessary precursor to learning other concepts and uses. Moreover, using crossword puzzle practices can help raise awareness of learning science vocabulary and increase engagement with vocabulary learning, providing various contexts to practice the use of the learned words and terms. These conditions are likely to be beneficial for vocabulary instruction. For pedagogical contribution, this helps the teacher understand to what extent students will benefit from the practice and to know their opinion towards the practice. The teacher may use the results to develop and adjust their teaching to help students learn science vocabulary effectively in the content-based classroom.

Conclusion

Secondary school students' science vocabulary knowledge can be improved by using Science Vocabulary Crossword Puzzle (SVCP) practices. This research provides evidence that vocabulary skills can also be improved in the content-based classroom. Teaching materials can be revised, for instance, incorporating crossword activities in every science content unit. This will strengthen the support system for students learning of English. The researcher could act as a change agent, playing the role of introducing this innovative method to other science teachers and other departments. The results can be used to convince other content teachers to try implementing this innovation in their lesson plans and materials.

Additionally, this innovation is compatible with the instructional environment because the students in this program use English as the medium of instruction, and crossword puzzle practice can be utilized to encourage students in their development of content knowledge. Furthermore, the process of designing and implementing the innovation is not complex. Hence, regarding compatibility and complexity, this innovation can be considered to be an innovation that promotes science vocabulary instruction. The researcher believes that other teachers may feel motivated to apply this innovation to target lesson units or vocabulary that they want to teach their students. Feeling part of the instructional change, teachers' beliefs and attitudes toward vocabulary instruction in the content-based classroom may also change.

Recommendation

Since this research is a small-scale project, there were only seven practices and short activities. The study time might not be sufficient to affect meaningful changes. However, the results showed significant and positive findings. Therefore, a larger-scale study over a longer period, such as a semester, or more lessons on a wider variety of science topics and their unique vocabulary, would offer even more benefits to the students and perhaps provide different results and feedback. Asking students to predict the meanings of words and compare their predictions with other students and with their teacher can strengthen learning. Interdisciplinary approaches that blend literacy lessons with science can also support science literacy (Grant and Fisher, 2010).

Moreover, students' performances after implementing the SVCP practice should be assessed for pronunciation or speaking skills development. Science Vocabulary Crossword Puzzle was found to be a fun and meaningful activity to teach content vocabulary. It might lead to enhancement, not only of vocabulary, but also some other areas of language learning, including reading, writing, listening, and speaking. Therefore, future research can go beyond vocabulary to investigate other areas of language learning.

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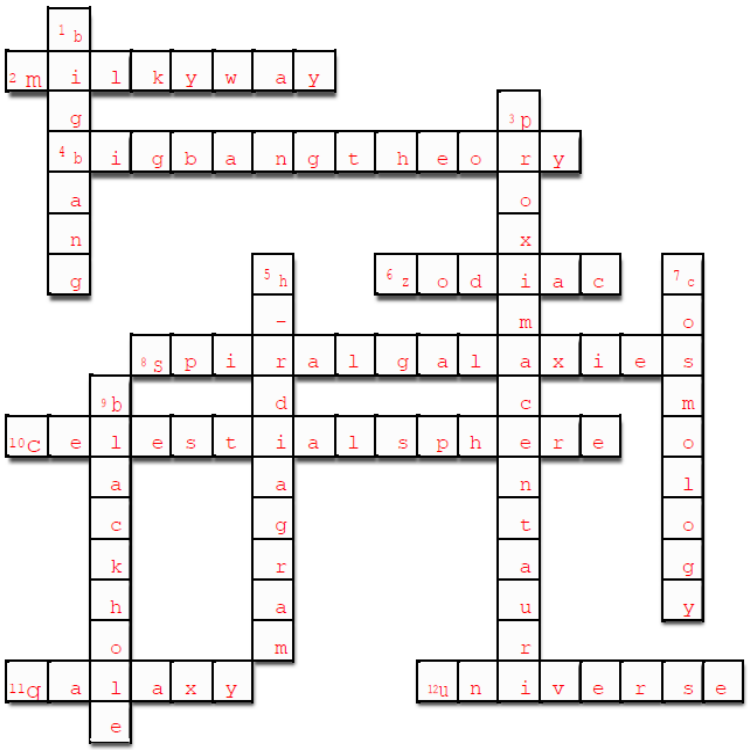
Appendix A

Sample of Science Vocabulary Crossword Puzzle (SVCP)

Stars , Galaxies , and the Universe

Complete the crossword puzzle below



Across

2. The name of our galaxy and to refer to the band of light we see in the sky when we look into the plane of our galaxy. (**milky way**)
4. The theory that all matter and energy in the universe was compressed into an extremely small volume that 13 billion to 15 billion years ago exploded and began expanding in all directions. (**bigbang theory**)
6. The apparent path at the Sun traces annually on the celestial sphere. (**zodiac**)
8. Galaxies that look like flat white disks with yellowish bulges at their centers. The disks are filled with cool gas and dust, interspersed with hotter ionized gas, and usually display beautiful spiral arms. (**spiral galaxies**)
10. The constellations on the celestial sphere through which the ecliptic passes. (**celestial sphere**)
11. An extremely large collection of stars held together by gravity. (**galaxy**)
12. All of matter and energy. (**universe**)

Down

1. The name given to the event thought to mark the birth of the universe. (**bigbang**)
3. The star that represents our nearest stellar neighbor in the universe and is a red dwarf about 4.3 light-years from the Sun. (**proximacentauri**)
5. Hertzsprung-Russell diagram, a graph that shows the relationship between a star's surface temperature and absolute magnitude. (**h-rdiagram**)
7. The study of the overall structure and evolution of the universe. (**cosmology**)
9. A place or an object with extremely high density, mass and gravity that can attract everything even light cannot escape its gravity. (**blackhole**)

Appendix B: **Samples of Research Instruments**

(1) Science Vocabulary Knowledge Test (30 items) (30 marks)

Objective: To measure vocabulary recognition and meaning **Time:** 40 minutes

Part 1 Matching Format (10 items)

Directions: *Match the word from the word blank with the definition below.*

star	Sun	Constellation	galaxy	solar system
planet	revolution	axis	rotation	inner planet
moon	lunar cycle	outer planet	asteroid	comet
meteoroid	telescope	quarter moon	waning	waxing
Satellite	crescent moon	gibbous moon	full moon	new moon

Asteroid	1. A piece of space rock too small to be a planet around the sun
Revolution	2. One complete turn around the object
Wanning	3. Getting smaller
New moon	4. Moon phase occurs when the Earth is between the Sun and the Moon
Galaxy	5. A large group of stars, dust, and gases held together by gravity
Satellite	6. A natural or artificial object that revolves around another object in space
Telescope	7. A tool that makes distant objects appear closer

Part 2 Translation (10 items)

Directions: *Translate an underlined word into your first language*

Solar Eclipse: สุริยุปราคา
High Tide: น้ำขึ้น
Space Shuttle: ยานขนส่งอวกาศหรือกระสวยอวกาศ
Zodiac: กลุ่มดาวจักราศี
Astronomy: ดาราศาสตร์

(2) Students' Opinion Questionnaire

Part I: General information

Gender: Male ☐ Female ☐

Part II: Opinions toward learning vocabulary through learning conditioned narrow reading

Description	**Strongly agree (4)**	**Agree (3)**	**disagree (2)**	**Strongly disagree (1)**
I enjoy doing crossword puzzle activities in science classes				
Doing crossword puzzle activities help me improve science vocabulary				
Doing crossword puzzle is useful tools to learn science				
Doing crossword puzzle help to stimulate memory power				
In other science lessons, doing crossword puzzle will be interesting				
There should be a huge collection of such crossword puzzle activities in science				
Doing crossword puzzle will be more effective in competitive form				

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