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# DEVELOPING READING COMPREHENSION SKILLS IN ENGLISH THROUGH CHEMISTRY EXERCISES

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**Abstract.** English reading comprehension skills play an important role in understanding and discovering chemical knowledge, which is the foundation for high school students to access world knowledge in the period of international integration. However, the survey results on the English reading comprehension ability of students majoring in Chemistry at some schools are still limited. In this article, a rubric for assessing the reading comprehension of chemistry in English for high school students has been proposed with seven criteria, and each criterion has three levels. This article proposes the process of building chemistry reading comprehension exercises in English. The research results have been pedagogically tested, showing that the exercise has a good effect on the development of chemical reading comprehension skills in English for high school students.

***Keywords:*** reading comprehension skills, Chemistry, exercise, high school student.

## 1. Introduction

Teaching natural sciences in English is being focused on to meet the need for international integration in the fields of education and science. The Ministry of Education and Training has issued Decision No 2658/QD-BGDĐT on the implementation of the Scheme on teaching and learning foreign languages in the national education system for the period 2017 - 2025 [1].

About 60 countries and territories use English as an official language in the world. Many countries use English to teach Science subjects in high schools such as India, Hong Kong - China, the Philippines, Singapore, Ireland, England, Wales, Scotland, Canada, Jamaica, the United States of America, Puerto Rico, Liberia, South Africa, Zimbabwe, Australia, New Zealand, Israel, Malaysia, Brunei, Costa Rica, and Sri Lanka. Several authors in Vietnam have been interested in developing chemistry reading comprehension skills in English for high school students. Cao Cu Giac and Pham Ngoc Tuan studied the reality of teaching chemistry in English in Vietnam [2]. Since then, chemistry exercises have been designed to develop English reading comprehension skills [3-5]. In the Programme for International Student Assessment (PISA), reading comprehension is one of the important competencies that are considered [6]. Pham Ngoc Tuan (2020) has proposed a rubric to evaluate reading comprehension chemistry skills in English [7]. Patrick E. Croner (2003), proposed strategies for Teaching Science Content Reading[8]. Tseng, Yu-Jan, et al. discussed Scientific Inquiry Performance in Chemistry through reading and evaluative reflection [9]. Childs P. E., Markic S. and Ryan M., (2015), highly appreciated the role of language in learning and teaching chemistry [10]. Some authors have reviewed reading comprehension skills, vocabulary, and their role in education [11-15]. Wu Hsiao Ping, Esther Garza,

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and Norma Guzman studied the challenges faced by international students, including Vietnamese students, when studying at universities in the United States. Among those challenges are differences in language and culture [16].

Chemistry reading skills in English play an important role in understanding and discovering chemical knowledge. However, there is not much research on developing English reading comprehension skills through chemistry exercises. This paper introduces the development of English reading comprehension skills through the design and use of chemistry exercises.

# 2. Content

## 2.1. Scope and methods of study

*Scope of study:* The content of the exercises is related to the Chemistry Curriculum 2018 and meets the learning outcomes of the curriculum. We conduct investigations, surveys, and pedagogical experiments within the scope of several typical senior high schools located in Hanoi.

*Study methods:* The study uses theoretical research methods, practical methods, transfer methods, and statistical methods. The paper will analyze the theoretical and practical basis of practicing reading comprehension skills by chemistry exercises in English After that, the research proposes the step-by-step procedure of building chemical reading comprehension exercises in English.

## 2.2. Developing reading comprehension skills in teaching Chemistry in English at High schools

### 2.2.1. The reality of using chemistry exercises to develop reading comprehension skills

Chemistry exercises include chemical questions or problems that help students both grasp and perfect a knowledge or skill. Chemistry exercises are one of the most effective tools to guide students to apply knowledge learned in class into practice; review, consolidate, and systematize knowledge; deepen, develop the learned knowledge and practice chemical skills; develop cognition and intelligence; increase the activeness and independent of students and form an effective learning method; educate ethics, manners, build up patience, honesty, scientific accuracy, and creativity, scientific working style (organized, planned, etc.); and create interest in learning the subject.

Teaching chemistry in English plays a vital role in providing knowledge and practicing English skills. Therefore, in teaching chemistry in English, teachers, and learners need to employ different teaching methods to improve teaching effectiveness. Finding out the reality of teaching chemistry in English in high schools is a scientific basis for the comprehensive development of students' skills in learning English. By reading an adapted text, students develop an understanding of chemical phenomena in a specific context. This engagement is assumed to help enhance students' chemical understanding.

Before giving the experimental exercises, a pre-test survey is prepared to understand the actual exposure of reading comprehension in Chemistry in high school and the frequency of encounters.

The two pie charts in Figs. 1 and 2 depict that most students in high schools have been exposed to Chemistry in English; however, the frequency of approaching in Figure 2 witnessed the opposite trend. The proportion of people who have a chance to learn Chemistry in English is 72.2% while only 17.6% of students say they often have access to Chemistry in English, and the rest say no in the second pie chart. This suggests that despite the actual exposure to Chemistry in English among a large number of students, they don't have many opportunities to approach this

subject frequently. It is important to figure out what challenges students are likely to face during English reading exercises before doing our experimental tasks and further measures to improve.

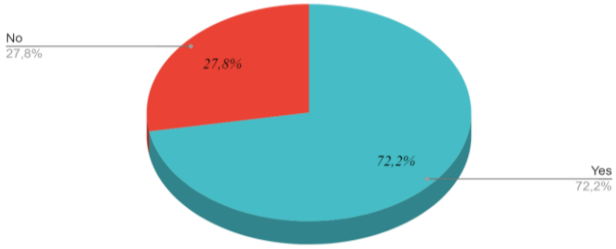



***Figure 1. The actual exposure of Chemistry in English in high schools***

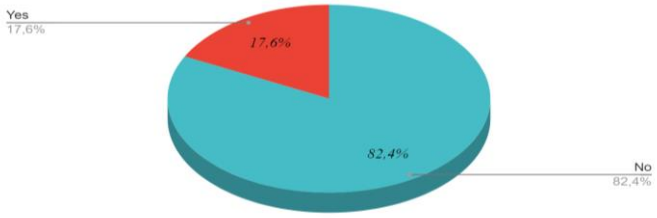



***Figure 2. The frequency of encounters***

Another survey about the difficulties students faced in general English comprehension exercises, and English chemistry exercises was also conducted.

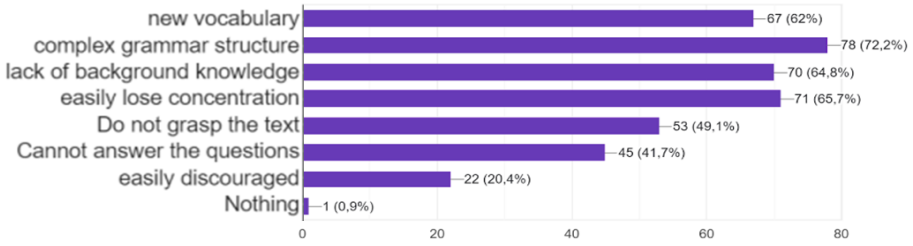



***Figure 3. The difficulties students encounter during reading comprehension in general English***

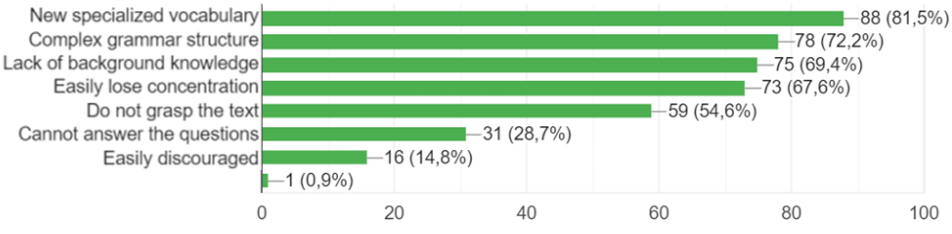



***Figure 4. The difficulties students encounter when practicing English reading comprehension with chemistry exercise***

Both Figure 3 and Figure 4 show the challenges students face in reading comprehension but one is in general English and the other is in Chemistry context-based. Hence, it shows that reading comprehension in chemistry in English also meets a lot of difficulties similar to general English. However, as Figure 3 shows, the biggest challenge in reading comprehension in general English is complex grammar, but in terms of Chemistry comprehension, the dimension of vocabulary in chemistry is pointed out. The greatest issue is that chemistry differs in several areas from the students' everyday language. In the language of chemistry:

- The majority of words stem from Greek or Latin, which are languages that are no longer familiar to the majority of the students, e.g., synthesis, electrolysis; etc.

- There are double-meaning words – words having different meanings from their everyday use when used in a specific scientific context, e.g. matter, solution, element;

- There is a technical and specialized vocabulary of science (e.g. names of laboratory equipment, nomenclature), rarely met in everyday life, which is like learning a foreign language;

- There is a complex symbolic language of chemistry;

- There is frequent use of mathematics, often connected to abstractions (e.g. equations, operations), with specialist vocabulary and symbolic language;

- Students are asked for the interpretation and labeling of graphs, diagrams, flow charts, etc. within a scientific context;

- There are specific logical argumentation patterns in scientific arguing and writing, e.g. in a laboratory report or scientific paper.

Another thing to point out is the slight increase in the number of students who are easily distracted and lack background knowledge. This has yet proposed another problem that requires teachers to tackle, which is students' enthusiasm and attention span in chemistry lessons.

### 2.2.2. Developing a rubric for English chemistry reading comprehension skills

**** Process of building a rubric***

Step 1: Researching the document

Collect and research documents related to the problem of training reading comprehension skills in Chemistry in English [6, 7, 12].

Step 2: Drafting a rubric for assessing chemistry reading comprehension skills in English

- Identify reading comprehension skills in English.

- Develop criteria for each skill in reading Chemistry in English.

- Decide the level of each criterion in each skill.

Step 3: Seeking expert advice

- Use the survey method with questionnaires to consult chemistry teachers in high schools, and experts in theory and teaching methods of chemistry about the rubric for assessing reading chemistry comprehension skills in English about the rationality, science, and feasibility of the criteria.

Step 4: Testing

- Testing in some high schools in Hanoi aims to check the feasibility, objectivity, science, and reliability of the criteria.

- Conduct statistical processing.

Step 5: Finishing

After conducting experiments in high schools, edit, supplement, and complete the rubric to ensure it is scientific and effective.

**** Rubric for English chemistry reading comprehension skills***

The Programme for International Student Assessment (PISA) reading literacy assessment is built on three major task characteristics to ensure a broad coverage of the domain [6]:

- Situation, which refers to the range of broad contexts or purposes for which reading takes place.
- Text, which refers to the range of material that is read.
- Aspect, refers to the cognitive approach that determines how readers engage with a text.

The PISA, 2015 has divided 07 levels of reading comprehension skills from 262 - 698 points. However, this is just general reading comprehension for 15-year-olds [6]. Pham Ngoc Tuan, in his doctoral thesis, proposed a rubric for assessing the reading chemistry comprehension skills in English with 10 components, and 60 criteria with 5 levels each [7]. In another approach, Charles Perfetti & Suzanne M. Adl proposed five criteria for reading comprehension from word to text [12].

In this article, a rubric for assessing the reading comprehension of chemistry in English for high school students has been proposed with 7 criteria, and each criterion has 3 levels.

***Table 1. Rubric for assessing the reading comprehension of chemistry in English***

| **Comprehension skills** | **Descriptive** | **Level 1 (1 point)** | **Level 2 (2 points)** | **Level 3 (3 points)** |
|---|---|---|---|---|
| Skill 1. Word Identification | Word identification is a critical first component of reading comprehension. The ability to accurately and automatically identify sight words and apply decoding strategies to read unfamiliar words is word identification. | | | |
| Skill 2. Knowledge of the chemical language | Knowledge of chemical symbols, formulas, reaction equations, nomenclature, and terminology. | | | |
| Skill 3. Inferences | To make sense of a text, skilled readers make inferences that connect elements between the lines of the text, find clues, and build meaning where information is not explicitly stated or otherwise supports the coherence necessary for comprehension. | | | |
| Skill 4. Skimming and summarizing main ideas | Previewing a text, document or book allows you to grasp the broader picture, get the author's main idea, and sketch important concepts. | | | |
| Skill 5. Exploiting chemical knowledge learned, connecting and inferring | Discovering chemical knowledge learned, and connecting it to the context of the text. | | | |
| Skill 6. Knowledge of chemical basis concepts | Understanding and interpreting chemical basis concepts in the text. | | | |

| | | | | |
|---|---|---|---|---|
| Skill 7. Reflecting and evaluation | Reflecting and evaluating chemical text involves drawing upon knowledge, ideas, or attitudes beyond the text to relate the information provided within the text to one's own conceptual and experiential frames of reference. | | | |

**2.2.3. The process of building chemical reading comprehension exercises in English**

**** Step-by-step process of building exercises***

*Step 1.* Determining the purpose

The ultimate goal of the exercise system is to enhance reading comprehension skills, so that students may approach exercises, examine practical abilities, and assist students in grasping knowledge via the completion of prescribed tasks.

*Step 2.* Identifying the contents and knowledge related to the exercise

The content of the exercise is related to the *Chemistry Curriculum 2018* and meets the learning outcomes of the curriculum. To meet the chapter's objectives, the teacher must be able to answer the following questions:

- Where is it located in the lesson?
- Is there a link between old and new knowledge?
- Is it suitable for students' cognition levels?
- What is the type of exercise?

Some types of exercises to improve reading comprehension skills in teaching chemistry in English at high schools:

- Fill in the gaps with the given word.
- Fill in the gaps.
- Use the information provided from the assignment data.
- Quantitative calculations.

*Step 3.* Building exercises

First, teachers need to collect the needed materials for developing exercises. The sources from this material can vary, including textbooks, research papers, written articles,… related to the chosen topic. The excessive amount of materials with great depth can assist the process of building exercises to be faster and more reliable.

In the exercise, teachers build the guide of the exercises; use diagrams and illustrations to attract students' attention; compose requirements, and questions (multiple choice or essay) according to a set of components that contribute to effective reading comprehension; re-solve the exercises; analyze the meaning; and evaluate the effects of each question as well as the exercise.

*Step 4.* Building a solution and conducting an experiment

Teachers build cohesive and detailed solutions for each question and determine its meaning, and how it can develop comprehension skills for students.

Teachers conduct experiments and evaluate reading comprehension skills according to each component skill for students after solving the exercises.

*Step 5.* Editing and adding supplements

After finishing the construction of the passage, the teacher checks the grammar and vocabulary, notes that the techniques and terminology of science must be correct; removes unnecessary, redundant facts; checks the content of the guide and question; corrects spelling mistakes; refinishes the instructions and questions; re-solve the exercises in different ways (if

any); analyze the meaning; and evaluate the effects of each question as well as the exercise.

Teachers discuss the correctness and appropriateness of the student's level with colleagues and experts.

**** First example***

*Step 1.* Determining the purpose

The exercise is designed to reinforce learned knowledge and inform new knowledge about Carbohydrates; test and evaluate the fundamental skills required for effective reading and comprehension: Word Identification; Inferences; Comprehension Monitoring; Comprehension Strategies; Vocabulary/ Lexical knowledge; and Word-to-text integration.

*Step 2.* Identifying the contents and knowledge related to the exercise

The main content of the exercise is "Synthetic modification of Cellulose" which is an extension to the knowledge of the chapter *Carbohydrate* in the Grade 12 Curriculum.

The related learning outcomes are:

- Presenting basic chemical properties of glucose and fructose (reaction with copper (II) hydroxide, bromine water, Tollens reagent, fermentation reaction of glucose, the specific reaction of the hemiacetal –OH group when glucose is in the loop form).

- Presenting starch metabolism in the body, formation of starch in plants, and application of some carbohydrates.

***Table 2. Identifying the contents and knowledge related to the exercise***

| **Where is it located in the lesson?** | **Is there a link between old and new knowledge?** | **Is it suitable for students' cognition levels?** | **What is the type of exercise?** |
|---|---|---|---|
| It is located at the end of the lesson. | Yes, students already knew carbohydrates (e.g. concept, natural state, properties, structural formula, application, and synthetic). | Yes, students are capable of using learned knowledge, reading, and analyzing the context of the exercise. After doing the exercise, students can broaden their knowledge about cellulose derivatives, the formula of each one, and the applications of the three mentioned cellulose. | Use the information provided from the assignment data. |

*Step 3.* Building exercises

Teachers collect relevant books, newspapers, articles, and research content related to social life that is attractive to students. The questions in the passage are arranged from easy to difficult to fit the students' abilities. Students were encouraged to answer the questions in small-group discussions which can promote students' activeness. A diagram is also included to make it easier for students to visualize the process.

**Read the following passage and answer the questions from 1 to 6.**

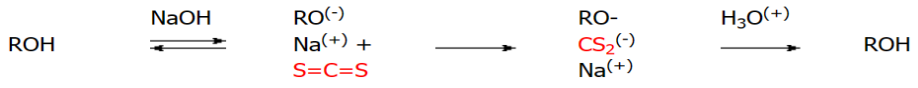
Cotton, probably the most useful natural fiber, is nearly pure cellulose. The manufacture of textiles from cotton involves physical manipulation of the raw material by carding, combing, and spinning selected fibers. For fabrics, the best cotton has long fibers, and short fibers or cotton dust are removed. Crude cellulose is also available from wood pulp by dissolving the lignan matrix surrounding it. These less desirable cellulose sources are widely used for making paper.

To expand how cellulose can be put to practical use, chemists have devised techniques for preparing solutions of cellulose derivatives that can be spun into fibers, spread into a film, or cast in various solid forms. A key factor in these transformations is the three free hydroxyl groups on each glucose unit in the cellulose chain, --$[C_6H_7O(OH)_3]$n--. Esterification of these functions leads to polymeric products having very different properties compared with cellulose itself.

Cellulose Nitrate first prepared over 150 years ago by treating cellulose with nitric acid, is the earliest synthetic polymer to see general use. The fully nitrated compound, --$[C_6H_7O(ONO_2)_3]$n--, called guncotton, is explosively flammable and is a component of smokeless powder. Partially nitrated cellulose is called pyroxylin. Pyroxylin is soluble in ether and at one time was used for photographic film and lacquers. The high flammability of pyroxylin caused many tragic cinema fires during its period of use. Furthermore, slow hydrolysis of pyroxylin yields nitric acid, a process that contributes to the deterioration of early motion picture films in storage.

Cellulose Acetate, --$[C_6H_7O(OAc)_3]$n--, is less flammable than pyroxylin, and has replaced it in most applications. It is prepared by reaction of cellulose with acetic anhydride and an acid catalyst. The properties of the product vary with the degree of acetylation. Some chain shortening occurs unavoidably in the preparations. An acetone solution of cellulose acetate may be forced through a spinneret to generate filaments, called acetate rayon, that can be woven into fabrics.

Viscose Rayon is prepared by the formation of an alkali-soluble xanthate derivative that can be spun into a fiber that reforms the cellulose polymer by acid quenching. The following general equation illustrates these transformations. The product fiber is called viscose rayon.




cellulose viscose solution rayon

*(Via: Introduction to Carbohydrates - Chemistry LibreTexts)*

Q1: (SKILL 4) What of the following could be the best title for the passage?

A. Properties of Cellulose
B. Some applications of Cellulose
C. Synthetic modification of Cellulose
D. Types of Cellulose.

Q2: (SKILL 1) The word “it” in paragraph 1 refers to

A. cotton dust
B. pure cellulose
C. wood pulp
D. crude cellulose

Q3: (SKILL 2) The word “ flammability” in paragraph 3 mostly means_____.

A. combustibility
B. cinematography
C. durability
D. immutability

Q4: (SKILL 6) According to the passage, _____ is the earliest synthetic polymer to see general use.

A. Cellulose Nitrate
B. Cellulose Acetate
C. Viscose Rayon
D. Acetate rayon

Q5: (SKILL 5) What is the formula of Cellulose Acetate?

A. $–[C_6H_7O(ONO_2)_3]n–$
B. $–[C_6H_7O(OAc)_3]n–$
C. $–[C_6H_7O(OH)_3]n–$
D. $–[C_6H_9(NO_2)O_5]n –$

Q6: (SKILL 7) Which of the following is TRUE according to the passage?

A. Due to its less desirable property, Pyroxylin has been overtaken in a majority of uses by Cellulose Acetate.
B. Each glucose unit in the cellulose chain contains at least three free hydroxyl groups.
C. The first synthesized Cellulose Nitrate was introduced over 16 decades ago by treating cellulose with nitric acid.
D. Short fibers or cotton dust are commonly used in paper-making factories.

*Step 4.* Building a solution and conducting an experiment

Here are the solutions to the exercise:

Q1. Answer: C

Meaning: Questions help students make sense of the text, make inferences that connect elements between the lines of the text, and find clues to determine what is the main content to correctly understand the text without confusion.

Q2. Answer: D

Meaning: The questions help students accurately and automatically identify sight words and apply decoding strategies to comprehend the stated word “it".

Q3. Answer: A

Meaning: This question helps students develop both lexical quantity and lexical quality, specifically involving knowledge of antonyms and synonyms in the chemistry language.

Q4. Answer: A

Meaning: The question helps students to develop word-to-text integration by the requirement

to link the phrase "earliest synthetic polymer " with an event established by the side clause of the sentence "Cellulose Nitrate, first prepared over 150 years ago by treating cellulose with nitric acid". In effect, the reader must treat "earliest synthetic polymer" as a paraphrase of " Cellulose Nitrate".

Q5. Answer: A

Meaning: This question also helps students use strategies in comprehension that is to look, think, and synthesize so that they can recognize the required specific information without having to read or understand the entire text. It also helps students observe, care, look for, and pay attention to chemical facts in reading. Specifically, there are different chemical compositions.

Q6. Answer: A

Meaning: This question helps students develop comprehension monitoring to verify their understanding and distinguish the accurate representation of the sentences in the text as well as the false ones.

*Step 5.* Editing and adding supplements (if needed)

**2.2.4. Second example**

*Step 1.* Determining the purpose

The exercise is designed to inform new knowledge or reinforce learned knowledge about Brønsted-Lowry theory of acid-base, depending on when it is used; test and evaluate the fundamental skills required for effective reading and comprehension as stated above: Word Identification; Inferences; Comprehension Monitoring; Comprehension Strategies; Vocabulary/ Lexical knowledge; Word-to-text integration.

*Step 2.* Identifying the contents and knowledge related to the exercise

The main content of the exercise is "Brønsted-Lowry theory of acid-base" which is in the knowledge of the chapter *Chemical Equilibrium* in the Grade 11 curriculum.

The related learning outcome is the State Bronsted-Lowry theory of acid-base.

***Table 3. Identify the contents and knowledge related to the exercise***

| **Where is it located in the lesson?** | **Is there a link between old and new knowledge?** | **Is it suitable for students' cognition levels?** | **What is the type of exercise?** |
|---|---|---|---|
| Teachers can use it before the lesson to inform new knowledge or after the lesson to reinforce learned knowledge | Yes, students already knew electrolysis, electrolyte, and non-electrolyte. | Yes, students are capable of using learned knowledge, reading, and analyzing the context of the exercise. After doing the exercise, students can broaden their knowledge about Brønsted-Lowry's theory of acid-base. | *Fill in the gaps with the given word* |

*Step 3.* Building exercises

Teachers collect relevant books, newspapers, articles, and research content related to the lesson. Teachers blank the important keyword while leaving out enough clues for students to decipher and fill in the correct word. The explanation for abbreviations is included for students to understand the text and chemical process better.

***Fill ONE WORD in the box at each blank***

| | | |
|---|---|---|
| *hydroxide ($OH^-$)* | *water ($H_2O$)* | *Acid* |
| *accept* | *Base* | *donate* |

The Brønsted–Lowry definition was introduced in 1923. This definition focuses on the transfer of $H^+$ ions in an acid–base reaction. Since an $H^+$ ion is a proton—a hydrogen atom without its electron—this definition focuses on the idea of a proton donor and a proton acceptor:

(1)_____: proton ($H^+$ ion) donor.

(2)_____: proton ($H^+$ ion) acceptor.

According to this definition, HCl is an acid because, in solution, it (3)_____ a proton to water:

$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$

This definition clearly describes what happens to the $H^+$ ion from an acid—it associates with a (4)_____ molecule to form $H_3O^+$ (a hydronium ion).

The Brønsted–Lowry definition also applies nicely to bases (such as $NH_3$) that do not inherently contain (5)_____ ions but still produce $OH^-$ ions in solution. According to the Brønsted–Lowry definition, $NH_3$ is a base because it (6)_____ a proton from water:

$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

_____

*aq: aqueous*

*l: liquid*

*Step 4.* Solving and conducting experiments

Here are the solutions to the exercise:

(1) Acid
(2) Base
(3) donate
(4) water ($H_2O$)
(5) hydroxide ($OH^-$)
(6) accept

Meaning: The exercise mostly requires students to utilize Skill 3 (Inferences) to fill in the missing information by connecting the information and finding clues given in the text. However, a complex integration of other comprehension skill components is also fundamental for students to finish.

For this paragraph:

"*According to this definition, HCl is an acid because, in solution, it (3)_____ a proton to water:*

*$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$*

*This definition clearly describes what happens to the $H^+$ ion from an acid—it associates with a (4)_____ molecule to form $H_3O^+$ (a hydronium ion).*"

The word "it" appears twice but with different meanings. This requires students to accurately identify sight words and apply decoding strategies to differentiate them: the first “it” represents HCl which gives out an $H^+$ ion, and the second one represents the $H^+$ ion (Skill 1).

This question also helps students use strategies in comprehension that is to look, think, and synthesize so that they can recognize the required specific information without having to read or understand the entire text. It also helps students observe, care, look for, and pay attention to chemical facts in reading, specifically here is the equilibrium in water. Students observe, look for, and pay attention to chemical facts in reading which display the background knowledge required to draw the inference, specifically here is the hydrolysis process. HCl gives out an $H^+$ proton and is left with a $Cl^-$ ion, identifying the answer to blank number (3) is “donate”. The water molecule is *associated* with the $H^+$ ion from acid to form $H_3O^+$, identifying the answer to blank number (4) is “water” (Skill 2 & 5).

These questions also help students to link the word to a referent established in a previous sentence “*(1)_____: proton ($H^+$ ion) donor… According to this definition, HCl is an acid because, in solution, it (3) donate a proton to …*”. Although “it” here represents“HCl”, students still have to treat “it” as a paraphrase of “ Acid” as “HCl” and “Acid” are similar terms, thus reaching the conclusion that acid donates a proton and filling “acid” in blank number (1) (Skill 2 & 6).

This question helps students to develop lexical quantities, specifically involving knowledge of related terms “donor” and “donate” in which “donor” implies the substance that donates its parts of the composition (Skill 2).

These questions help students to develop the ability to reflect on and verify their understanding of the written text, and decide whether their answer is correct and fits in with the text (Skill 7).

*Step 5.* Editing and adding supplements

**2.2.5. Exercises system**

We developed a total of 22 exercises within the nonmetallic topic of grade 11 and the metallic topic of grade 12. Students can use this exercise system via a QR code.

***Figure 5. QR code to our exercises***

## 2.3. Pedagogical Experiment

**** Survey goals***

We designed 3 survey projects to determine:

*Project 1.* Using a range of reading chemistry exercises aimed at assessing students’ chemistry understanding through the challenges students encounter when doing exercises.

*Project 2***.** Self-judgments on how challenging the texts are to read and about how what they have read impacts their preconceived notions.

*Project 3.* Assessing students’ improvement after reading chemistry comprehension through 2 given examples.

**** Context and participants***

A total of 108 students of 12th graders from Nguyen Tat Thanh High School participated in this quasi-experimental study. All the students were from a typical senior high school located in

Ha Noi. Supportive materials were created for high school education, which can be used by chemistry teachers in Vietnam and nationwide. The school authority randomly assigned students to each classroom. All of the students in the study consented to participate in the research and have their work analyzed and published.

**** Methodology***

This study's survey approach consisted of delivering the survey questionnaire directly to high school students. We utilized "Google Forms" to get started with the survey procedure, as well as to handle and analyze the data. At the end of the survey, the data was collected and compiled.

**** Survey process***

*- Survey steps*

The study is based on the assessment of students' responses to a pre-test and a post-test.

*Project 1:* Experimenting and Evaluating reading comprehension

Project 2: Practicing reading comprehension skills in learning chemistry in English.

*Project 3***:** How much reading comprehension in Chemistry exercises helps students to improve their English competency and the importance of reading comprehension in Chemistry in English.

*- Data analysis*

Project 1: Experimenting and Evaluating reading comprehension

Exercise 1:

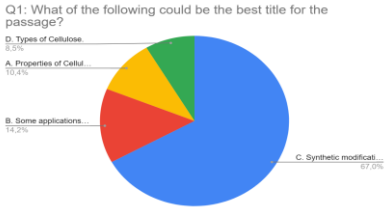



***Figure 6. Students' answers to Question 1***


***Figure 7. Students' answers to Question 2***

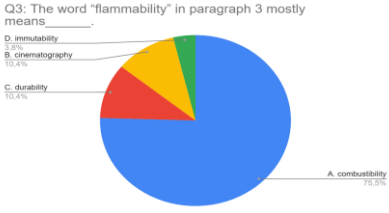



***Figure 8. Students' answers to Question 3***

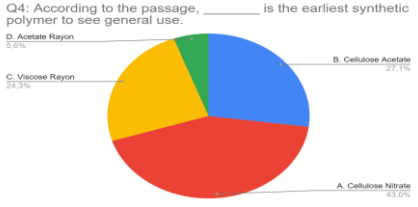



***Figure 9. Students' answers to Question 4***

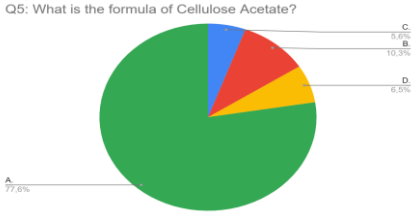



***Figure 10. Students' answers to Question 5***

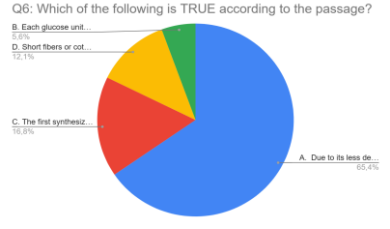



***Figure 11. Students' answers to Question 6***

Exercise 2:

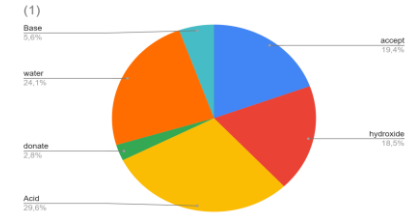



***Figure 12. Students' answers in Blank (1)***

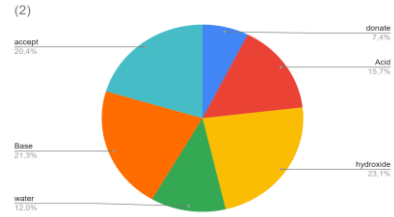



***Figure 13. Students' answers in Blank (2)***

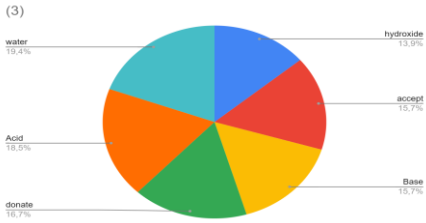



***Figure 14. Students' answer in Blank (3)***

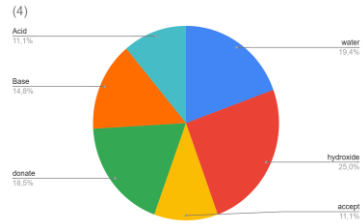



***Figure 15. Students' answers in Blank (4)***

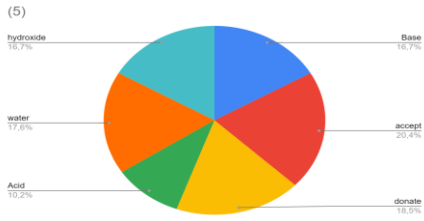



***Figure 16. Students' answers in Blank (5)***


***Figure 17. Students' answers in Blank (6)***

All of the figures above show the percentage per answer for each question in Exercise 1 and Exercise 2. These indicate that students generally excel in one component of reading comprehension skills as shown in the percentage of right answers in Exercise 1. However, when it comes to a higher level of integration and utilization of various skill components and chemistry competence, the result starts to decline as the number of participants with correct answers for each question is significantly lower than that in Exercise 1.

Project 2: Practicing reading comprehension skills in learning chemistry in English.

Before evaluating the level of awareness of educational objects on the use of reading comprehension skills in chemistry in English, students are asked to do 2 reading exercises in English. The collected data prove that a majority of students find it difficult to do the tasks (62%). 26,9% of them say it is extremely hard.

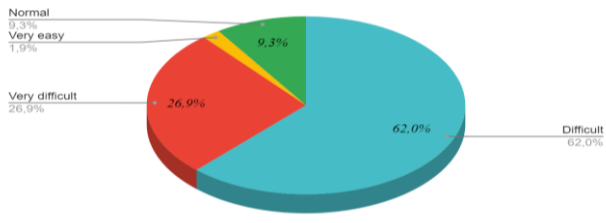



***Figure 18. The feeling of students about the exercises***

This result contradicts a prior project finding in which respondents were questioned about the challenges they had while practicing reading comprehension chemistry in English. It is important to figure out the reasons and try to help them to improve their reading skills. Hence, we decided to delve deeper to understand this contradiction and to evaluate it more accurately by asking them about their experiences with doing the tasks.

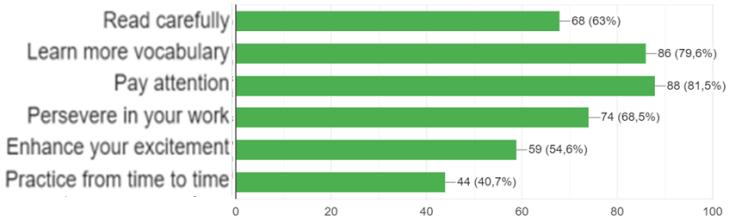



***Figure 19. The experiences received after the experiment***

Most students agree that they need to concentrate on the exercises and follow the information during the tasks to find out the keywords, and the answer. Moreover, one of the important things is to learn more vocabulary which is technical and specialized in Chemistry. Last but not least, the role of reading comprehension in Chemistry is also mentioned in our study.

Project 3: How much reading comprehension in Chemistry exercises helps students to improve their English competency and the importance of reading comprehension in Chemistry in English.

Based on the above research results and the surveyed and tested data, we let students self-assess their competency in reading comprehension abilities while learning chemistry in English in high school.

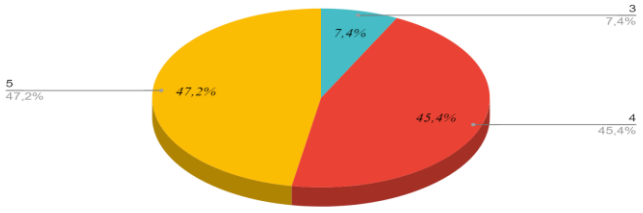



***Figure 20. Students self-assess their improvement in reading comprehension skills on a scale of 5 after completing Chemistry exercises***

Our investigations of student reading practices revealed that engaging students in reading and discussing contextual scientific passages could be supportive of advancing student inquiry competency. Evidence is given, almost half of the students choose 5 out of 5 for self-improvement (47,2% ), the other half assess 4 out of 5 (45,4%), and others choose 3 out of 5.

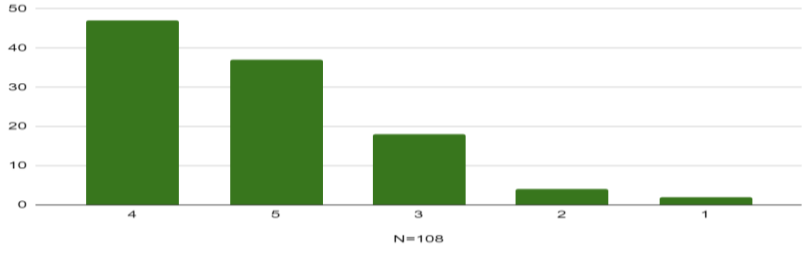



***Figure 21. The importance of reading comprehension skills in chemistry exercises in English***

We conducted a preliminary survey to figure out students' opinions on the importance of reading comprehension in chemistry in English. There were five levels of evaluation: (5) very important (1) Not important. As Figure 20 shows, the result demonstrates the importance based on the post-questionnaire.

- *Survey results*

+ Effective for students:

About the above projects, the exercises required a different, more abstract way of thinking, and regarded the knowledge background as challenging, but doable for the students who want to make the effort. Moreover, students agreed that chemistry exercises were difficult to understand. However, they could work smoothly on the assignments if they learned more vocabulary related to chemistry knowledge and paid more attention. Hence, they needed to read and understand the exercises and the underlying theory clearly before choosing answers.

+ Supportive for teachers:

The study analyzed the effectiveness of doing Chemistry exercises in English to be able to foster deeper student understanding. This is particularly important because teachers can offer appropriate methods to improve students' reading skills through Chemistry exercises. It also made teachers evaluate their regular practice.

+ Mythological reflections and further plan:

The study is still in its initial state. The affordances and constraints of the employed procedures must be considered while analyzing the outcomes. Further improvements in the study as well as the number of survey participants are within our plan.

## 3. Conclusions

Chemistry reading comprehension skills in English are increasingly important in chemistry learning and teaching in Vietnam. A survey of the current situation of teaching to develop reading comprehension skills in English of 108 grade 12 students in some high schools in Hanoi shows the urgency of the research topic. A rubric for assessing the reading comprehension of chemistry in English for high school students has been proposed with 7 criteria, and each criterion has 3 levels. The process of designing chemistry exercises has been proposed to develop students' reading comprehension skills in English. A system of chemistry exercises has been built to develop English reading comprehension in the non-metallic part of grade 11 and the metallic part in grade 12, including 22 exercises. Some chemistry exercises have been designed and tested, and initial results show that they have a good effect on developing English reading comprehension ability. In the coming time, we will continue to develop a system of chemistry exercises to improve English reading comprehension skills for high school students.

The results of the present study are only a first step as this study focused on a group of Hanoi students at a particular school. Therefore, the generalizability of these results outside Hanoi is limited. Due to time and language limitations, this study has not described in detail the levels of each criterion in the rubric. Future studies should consider supplementing and applying to other contents of the 2018 high school chemistry curriculum.

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