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Learning Chemistry in English: The Relationship between Language Skills and Learning Outcomes

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Abstract: The study aims to analyze the relationship between English language skills and the students' learning outcomes in chemistry learning that uses English as the medium of instruction (EMI). This qualitative descriptive study was conducted on 40 high school students. Data is collected and analyzed in the form of the test result of the language skills and learning outcomes. The results for students' language skills: 75 % of students are at level A2 (primary user), 15 % are at level B1 (intermediate), 5 % are at level B2 (upper-intermediate), and 5 % are at level C1 (advance/proficient user). The students' chemistry learning results are averagely low, i.e., 70 % of students gained a score under 75 as the minimum criteria of standard learning, only 30 % of students reached the score above the KKM (Criteria of Minimum Competency). The conclusion of this research is that there is a relationship between language skills and chemistry learning outcomes. Learning chemistry in English has not given good results for students' learning outcomes. Therefore, the demands of learning in English need to be supported by good language skills to understand the learning content.

INTRODUCTION

English, as a global language, has become an essential part of today's globalization era. Chung et al. (2014) stated that global language skill is one of the essential skills that one must have in this 21st-century and has been the main focus in many countries such as America, Australia, China, and Hongkong. This international language is the medium of instruction in various fields such as economics, health, military, and education. In education, English has been applied to various education levels, ranging from primary education to higher education (Merino & Lasagabaster, 2018). Science teaching and learning in English has become a trend (Galloway et al., 2020; Hu et al., 2014) and been widely applied in various countries such as Hongkong (Ortega et al., 2015), Taiwan (Yang, 2015), Spain (Bello-Orgaz et al., 2016; Guillamón-Suesta & Renau, 2015), Japan (Galloway et al., 2017; Yamano, 2013), Malaysia (Hasim & Barnard, 2018) and other countries.

The learning presented in foreign languages can have a positive impact on the students. Gulyas et al. (2015) stated that studying the concept of science as chemistry prepares students to participate in the modern era. Nowadays, many lectures and learning resources, such as textbooks or the internet, use English as the medium of instruction. Experience has shown that both the aspects of the language and the content (subject) can be effectively integrated into learning

(Banegas, 2012; Coyle, 2015; Heras & Lasagabaster, 2015; Mehisto & Wolff, 2010). It also can create a synergistic impact that means that students who like the language will remain motivated to learn even if they do not like the content, and vice versa. Students who are very fond of content (subject) will still get the language skills. Also, learning has a positive impact on improving academic language (Somers, 2017), learning motivation (Lasagabaster, 2019), conceptual knowledge (Huang, 2020; Ruiz de Zarobe & Zenotz, 2017), and reading literacy (Prieto-arranz et al., 2015).

Science learning, especially chemistry, using English as the medium of instruction has challenges and obstacles (Ball, 2018; Nawrot-lis, 2019). English skills become a factor to be aware of. However, good English mastery does not necessarily give good results in understanding the concept of chemistry and vice versa. The language used in science is usually different from everyday languages (Msimanga & Erduran, 2018). For example, in chemistry, 'solution' means *larutan* (in Bahasa Indonesia), while in a daily conversation, the solution could mean the answer to a problem. Supriatna et al. (2019) stated that the concept could be understood more easily when having a positive attitude toward the learning resource. Therefore, it is necessary to analyze in-depth whether English skills positively impact understanding the concept of chemistry or that there is no connection between the two.

The method of learning chemistry using English is undoubtedly different from learning chemistry with the local language (Bahasa Indonesia). Some studies have claimed that there are two acquisitions content and language (Bell et al., 2016; Mesa, 2014). Besides, the use of textbooks in this learning becomes an essential factor. Not all English-speaking textbooks can be easily understood and learned by students (Purnama et al., 2019). Moreover, Vithanapathirana & Nettikumara (2020) explained the difficulty in finding learning resources in bilingual schools. Therefore, it is necessary to select textbooks and learning methods suitable for teachers and students in learning.

Learning science in English that has many positive impacts is the demands of individual schools with international school characterization. However, in the teaching-learning activity, it was found that the students feel difficulty in understanding the concept of chemistry while using English as the medium of instruction. Students have difficulty in understanding the scientific language of chemistry and abstract concepts described in English. Also, the teaching materials used have not been able to accommodate students' needs both in terms of teaching materials and the exercises on the learning materials. These findings are rarely discussed and evaluated in Indonesia's journal articles, whereas learning in bilingual schools is essential.

The obstacles in learning science using a foreign language are found in various countries as well. For example, Albakri (2013) stated that students face some obstacles in understanding science texts using English in a high school in Dubai where their native language is Arabic. Unlike the research of Albakri, Ruiz de Zarobe & Zenotz (2017) study at a school in the Spanish Autonomous Community concluded that learning using the global language could improve concepts as speaking skills, especially in student's reading skills. Besides, Yassin et al. (2010) study on teachers teaching Malaysian schools gives us information that students in the school are only involved in low-level cognitive learning (C1-C2).

Analysis that has been done from various research findings on science learning in English increasingly strengthens that the impact caused is very

diverse. The obstacles encountered are very diverse, as well. Therefore, it is also necessary to study through research about the implementation of science learning, especially chemistry, that uses English as the medium of instruction. It has been explained that learning science in a global language is a demand in today's globalization era. Therefore, the analysis of ongoing learning must be undertaken to determine the success of the learning.

This study's main objective is to analyze the relationship between language skills and learning outcomes in chemistry class that uses English as the medium of instruction. Language skills analyzed are students' English language skills tested through a series of language skill tests. The learning results analyzed are the results of the chemistry learning obtained by students through a series of study results tests. Moreover, this study will analyze the relationship between language skills and learning outcomes.

METHOD

The research method used in this study is qualitative descriptive. Moleong (2007) stated that qualitative research is a procedure that generates descriptive data of written or spoken words from people and behaviors that can be observed. This study will examine language skills, chemistry learning outcomes, and students' feedback. The subject of this study is 40 students in tenth grade at SMA (Senior High School) Cahaya Rancamaya, Bogor, Indonesia. The selection of students was done by purposive sampling (Arikunto, 2006). Data is obtained through English proficiency assessment tests, exercises to measure the results of the chemistry learning, and questionnaires for students' feedback.

English proficiency test uses TOEFL test instruments. The aspects measured in this test include reading and listening skills. The score is categorized into four levels according to the Common European Framework of Reference (CEFR), which is a primary user, intermediate, upper-intermediate, and expert user (advance). The score for primary users is between 337-459. The score for intermediate skills is between 460-542. The score for upper-intermediate is between 543-626. The score for expert users is between 627-677 (Trim, 2011).

Tests on chemistry learning results use multiple-choice test instruments of 30 with four options in every question. Each correct answer is given a score of 4, so the maximum score is 100 points. The score gained is categorized into two; the high when reaching the score above 75, and the low when reaching the score below 75. The selection of number 75 refers to the minimum criteria of mastery learning (KKM). The instrument has been validated by the expert with a percentage of 95 % validity. The English questions are compiled from teaching materials that have been used during chemistry learning so that the tests have been following the authentic assessment techniques. The questions consist of 6 indicators, namely state the specific properties of solids, liquids, and gases; Describe the structure of solids, liquids, and gases in terms of particle separation, arrangement, and types of motion; Describe changes of state in terms of melting, boiling, evaporation, freezing, condensation, and sublimation; Explain changes of state in terms of the kinetic theory; Describe the pressure and temperature of a gas in terms of the motion of its particles qualitatively, and Describe and explain diffusion.

The questionnaire is aimed at knowing students' opinions about the essential aspects of learning chemistry in English. In the questionnaire, students must sort three factors in chemistry, from what they think is very important to the least important. These three factors are English skills, teaching methods by teachers, and teaching materials used. The questionnaire's data is analyzed by giving

score; high priority will get the score = 3, medium priority = 2, and low priority = 1.

RESULT AND DISCUSSION

Students' language skills analysis that refers to the Common European Framework of Reference (CEFR) divides the level of English language skills based on the TOEFL score. The results of students' language skills analysis are in Table 1.

Table 1. Students Language Skills

TOEFL ITP Score	CEFR Level	Number of Students
627 - 677	C1 (Proficient user/advance)	2 students (5 %)
543 - 626	B2 (Independent user, upper-intermediate)	2 students (5 %)
460 - 542	B1 (Independent user, intermediate)	6 students (15 %)
337 - 459	A2 (Basic User)	30 students (75 %)

Most of the students (75 %) have English skills at level A2 or Basic user (primary user). 15 % of students have a level of B1 or intermediate skills, 5 % of students have a level of B2 or upper-intermediate, and 5 % have a level of C1 or expert users (advance/proficient user). According to CEFR, students at level A2 can only understand the underlying idea in a short text using a simple vocabulary. Students at level B1 have clearly understood the intent of a short sentence/dialogue that uses some high vocabulary and phrases. At level B2, one of its features is that students can connect information obtained from multiple speakers in a short dialogue and identify the underlying idea in a long speech. While at level C1, one of the indicators is that students can understand the basic idea and detailed information in a speech/conversation consisting of abstract and challenging vocabulary that requires integration and language synthesis.

After analyzing students' language skills in chemistry learning, further analysis of student learning outcomes is conducted. The tests conducted on tenth-grade students were obtained by the high score group and low score group of students. A high score is achieved if the student manages to score 75 upwards, while the low score is below 75. The percentage of chemistry learning results can be seen in Figure 1.

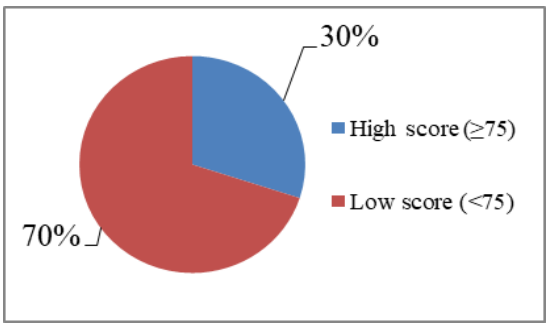


Figure 1. The Percentage of Students' Learning Outcomes

In addition to seeing the percentage results in general, an analysis of each test question was carried out. The results data is shown in Table 2.

Table 2. Analysis of the Percentage of Students in each Indicator

Indicator	Percentage of Students Who Passed the KKM
State the distinguishing properties of solids, liquids, and gases	75%
Describe the structure of solids, liquids, and gases in terms of particle separation, arrangement, and types of motion	55%
Describe changes of state in terms of melting, boiling, evaporation, freezing, condensation, and sublimation	60%
Explain changes of state in terms of the kinetic theory	48%
Describe the pressure and temperature of a gas in terms of the motion of its particles qualitatively	50%
Describe and explain diffusion	45%

Analysis of the correlation between language skills and the learning outcomes is carried out using a test paired sample t-test with a significance level of 0.05 using SPSS. The resulting data is shown in Table 3.

Table 3. Analysis of Correlation Test Paired Sample T-test

	N	Correlation	Sig.
Pair language skills & learning outcomes	40	0.467	0.038

Grouping students based on English skills and learning outcomes need to be done. To facilitate analysis, tenth-grade students' English proficiency will be divided into two large groups, namely the high group (B1-C1) and the low group (A2). The learning outcomes criteria are that students have high learning outcomes if the score is 75 or higher, whereas if the results of chemistry learning under 75, then students have poor learning outcomes. Hence, the classification of the categories are 1) Students with the high score of the language skills and the chemistry learning outcomes, 2) Students with high language skill scores but low chemistry learning outcomes, 3) Students with low language skill score but high chemistry learning outcomes, and 4) students with low language skill score and low chemistry learning outcomes. The number of grouping can be seen in Figure 2.

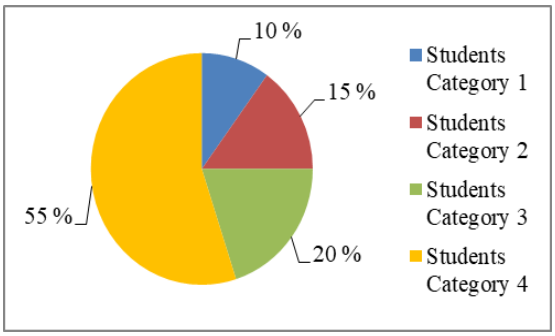


Figure 2. Percentage of Students' Classification of Language Skills and Learning Outcomes

There are as many as 55 % of students who have poor language skills and learning outcomes. This means that many students with poor English skills will have poor chemistry learning outcomes. Few students with low language skills have high learning outcomes, and few students with high language skills have poor learning outcomes.

After analyzing the correlation between language skills and learning outcomes, students are then asked to fill in the questionnaire. The questionnaire results are displayed in Table 4.

Table 4. The Questionnaire Result of the Students in Category 1

Aspects	Percentage (%)
English skills level	33.33
Teacher methods in teaching	33.33
Textbooks used	33.33

The percentage of the three essential aspects of chemistry learning in English is equal or balanced, which means that all three are, according to the students, having the same urgency (priority). The student opinion of Category 2 on the three essential aspects of chemistry learning in English can be seen in Table 5.

Table 5. The Questionnaire Result of the Students in Category 2

Aspects	Percentage (%)
English skills level	22.22
Teacher methods in teaching	38.89
Textbooks used	38.89

The highest percentage is on the teacher's method in teaching and textbooks used. It means, according to the students above, the most important aspect of chemistry learning in English is the teacher's method and textbooks used. The student opinion of Category 3 on the three essential aspects of chemistry learning in English can be seen in Table 6.

Table 6. The Questionnaire Result of the Students in Category 3

Aspects	Percentage (%)
English skills level	33.33
Teacher methods in teaching	41.67
Textbooks used	25.00

The highest percentage is on the teacher's method in teaching and textbooks used. It means, according to the students above, the most important aspect of chemistry learning in English is the teacher's method in teaching, then language skills and textbooks used. The student opinion of Category 4 on the three essential aspects of chemistry learning in English can be seen in Table 7.

Table 7. The Questionnaire Result of the Students in Category 4

Aspects	Percentage (%)
English skills level	33.39
Teacher methods in teaching	40.91
Textbooks used	19.70

The highest percentage is in the teacher's method of teaching. This means, according to the students above, the most important aspect of chemistry learning in English is the teacher's method in teaching, then the language skills of English and textbooks used. The students' overall questionnaire results from students' responses to three essential aspects of chemistry learning in English are presented in Figure 3.

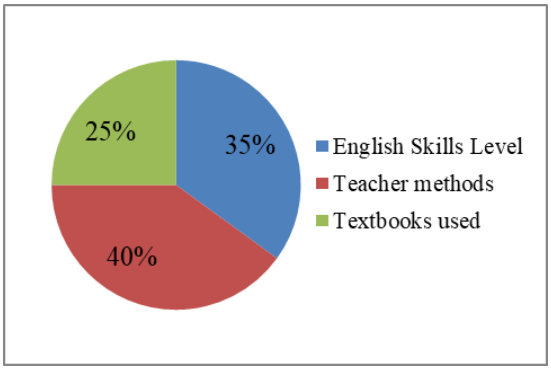


Figure 3. The Percentage of Students' Responses

From the results of the English proficiency of tenth-grade students, we can see that the average students (75 %) are still at the base level. This can be observed from the test results of language skills and observations as the learning progresses. The lack of language skills in chemistry learning with English as the medium of instruction is because students are not accustomed to using English in class. That means many students who have not had experience in class or at school where English is used in science learning. Lo & Macaro (2015) concluded that there were differences in language skills among students who had recently adopted bilingual learning with schools that had long adopted the learning. This factor of experience can affect language skills.

The students' chemistry learning outcomes are varied, but in general, chemistry learning results are still low, which is an average score of 52. In the First indicator, namely, state the specific properties of solids, liquids, and gases, 75 % of students can pass the KKM (Criteria of Minimum Competency). In this indicator, students are asked to name the different properties of solids, liquids, and gases through several questions. The different properties are related to the shape, volume, and compressibility. The examples of questions of this indicator can be found in question number 2.

QUESTION NO 2

Which state of matter has no definite shape and no definite volume?

A. Gas

B. Liquid and gas

C. Solid

D. Liquid

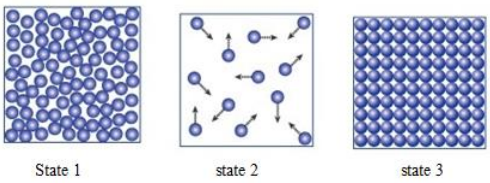
Figure 4. Question Number 2

Most students can answer correctly for this question, namely, choice A. The indicators do not need the ability to think positively. Students only need to remember the concepts that have been taught.

The second indicator describes the structure of solids, liquids, and gases in terms of particle separation, arrangement, and types of motion. The examples of this indicator can be seen in question number 5.

QUESTION NO 5

The diagrams show the arrangement of particles in three different physical states of substance X.



Which statement about the physical state of substance X is correct?

A. *Particles in state 1 vibrate about fixed positions*
B. *State 1 changes to state 2 by diffusion*
C. *State 2 changes directly to state 3 by condensation*
D. *The substance in stage 3 has a fixed volume*

Figure 5. Question Number 5

As many as 55 % of students have been able to answer correctly, namely choice D. The students have understood that state 3 is an arrangement of solid particles that are arranged in fixed regularly positions, so it has a fixed volume. Students who answered correctly to the questions above were also able to understand the scientific language that is in the problem. On the other hand, around 45% had difficulty understanding the purpose of the questions and answer options, even though they knew the shape and arrangement of particles in solid, liquid, or gas objects.

The third indicator describes changes of state in terms of melting, boiling, evaporation, freezing, condensation, and sublimation. The examples of this indicator can be found in question number 10.

QUESTION NO 10

What change of state is taking place in this photograph?

A. *Boiling*
B. *Freezing*
C. *Melting*
D. *Condensation*

Figure 6. Question Number 10

As many as 60 % of students can answer correctly to the question above, namely choice C. In the picture above, there is a lump of ice that is melting. This problem is relatively easy for students to understand. Short answer options with questions accompanied by pictures relating to daily life are relatively easy for students to understand.

The fourth indicator is to explain changes of state in terms of the kinetic theory. The examples of this indicator can be found in question number 15.

QUESTION NO 15

The diagram shows a cup of coffee.

Which row describes the water particles in the air compared with the water particles in the cup?

	Moving faster	Closer together
A	*√*	*√*
B	*√*	*X*
C	*X*	*√*
D	*X*	*X*

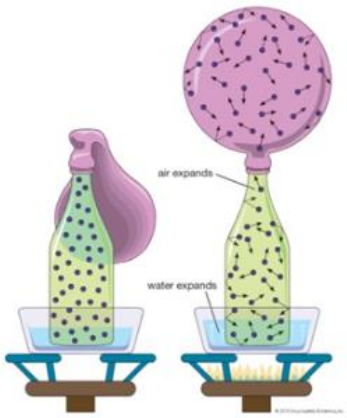
Figure 7. Question Number 15

In this question, only 48 % of students were able to answer correctly, namely choice B. In the problem, there was a cup of hot coffee. Steam is visible on the coffee. This means there is a phase change from liquid to gas. In particle theory, the liquid that turns into gas increases the particle's velocity and distance, so B the most appropriate choice. Most students have not been able to understand this problem well. This question indeed requires students to analyze the processes that occur in the picture and then conclude through the available choices.

The fifth indicator is to describe the pressure and temperature of a gas in terms of its particles' motion qualitatively. The examples of this indicator can be found in question number 18.

QUESTION NO 18

When you heat the gas, the particles take in heat energy and move even faster. They hit the walls more often and with more force. So the gas pressure increases. When you heat the gas in a closed container, its pressure and volume will increases.



What can you say about the picture above?
A. The volume of gas increase
B. The number of particles increase
C. The pressure in the balloon increases
D. A and C are correct

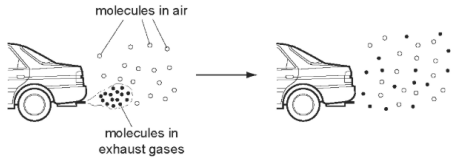
Figure 8. Question Number 18

The problem in Figure 8 requires students to understand the text of the reading about heated gas objects. After that, by paying attention to the balloon's image being heated, the students were asked to conclude the experiment related to the pressure and volume of the balloon. In the indicator, only 50 % of students can answer correctly, namely choice D, where the balloon's volume and pressure increase. Half the students were unable to answer due to their inability to understand the text given. Understanding the text is the key to answering the questions above.

The sixth indicator is to describe and explain diffusion. The examples of this indicator can be seen in question number 22.

QUESTION NO 22

The diagram shows how the molecules in the exhaust gases diffuse into the air.



Which statement describes what happens to these molecules next?
A. The molecules fall to the ground because they are heavier than air molecules
B. The molecules go back together as they cool
C. The molecules spread further into the air
D. The molecules stay where they are

Figure 9. Question Number 22

The problem in Figure 9 shows the case that occurred in car exhaust gases. The gas released by the vehicle will mix with the air that is around the car. The above process is a diffusion process. In this problem, only 45 % can answer correctly, namely choice C, where the molecules or particles of car exhaust gases will move away and mix with air particles. As many as 55 % have not been able to understand the concept of diffusion well. This is because this process requires good language skills and a good understanding of the concept as well.

The chemistry learning outcomes that are still low indicates that learning chemistry in English at SMA Cahaya Rancamaya, Bogor Indonesia, has not yet

provided good results towards students' learning outcomes. Poor learning outcomes indicate the number of obstacles students face, especially in understanding the English concepts and questions. Low learning results are also caused by differences in science language characters from daily language (Liu, 2018). Learning chemistry in English is a challenge for students. At the same time, students must understand the language of instruction and the lesson content taught.

The correlation analysis of students' language skills to the chemistry learning outcomes demonstrates the probability score (sig.) 0.038 (see Table 3), this score is less than the probability of α 0.05. This means that the correlation is significant. In other words, there is a relationship between the students' English language skills level and the students' chemistry learning outcomes. This is evident in the percentage of 55 % of students who have low language skills have low learning outcomes as well. Morton (2020) confirms that there is a relationship between language, content, and literacy. This means that students' language skills are crucial to support the learning outcomes of students. Good language skills will make it easier for students to understand lesson content to improve their learning outcomes ultimately.

In the analysis of the questionnaire, the highest percentage is on the teacher's method in teaching. This means that the teacher's method of teaching determines students' learning outcomes. It is necessary to study independently how the teacher's methods should be used in science learning in English. Then the second most crucial aspect in the English language skills of students. Many students realize that their language skills are low, so they get poor learning outcomes. The aspect of using teaching materials (books) is the third most important aspect by students in understanding the content of the chemistry learning that uses English as the medium of instruction.

CONCLUSION

This research concluded a relationship between English language skills and chemistry learning outcomes in chemistry learning that uses English as the medium of instruction. The conclusion was obtained from the correlation analysis indicating the probability score (sig.) 0.038 was less than α 0.05. It means that the correlation was significant. The chemistry learning outcome was low; therefore, it needs to improve students' language skills to increase the understanding of the content that ultimately improves learning outcomes.

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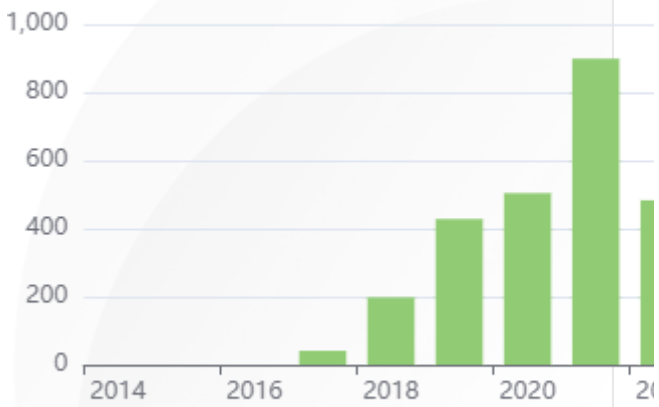

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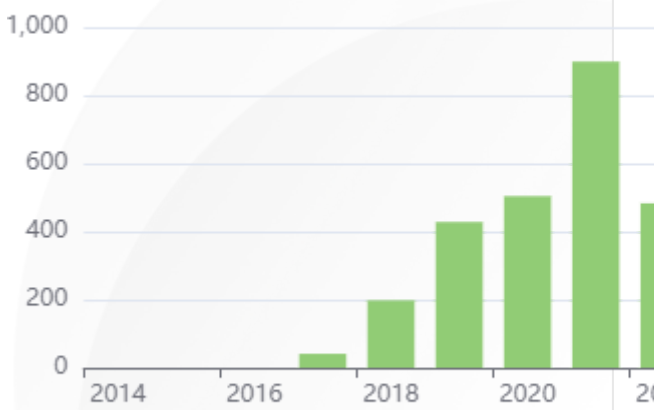

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Learning Chemistry in English: The Relationship between Language Skills and Learning Outcomes

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Rudi Firmayanto, Leny Heliawati, Bibin Rubini

Abstract

The study aims to analyze the relationship between English language skills and the students' learning outcomes in chemistry learning that uses English as the medium of instruction (EMI). This qualitative descriptive study was conducted on 40 high school students. Data is collected and analyzed in the form of the test result of the language skills and learning outcomes. The results for students' language skills: 75 % of students are at level A2 (primary user), 15 % are at level B1 (intermediate), 5 % are at level B2 (upper-intermediate), and 5 % are at level C1 (advance/proficient user). The students' chemistry learning results are averagely low, i.e., 70 % of students gained a score under 75 as the minimum criteria of standard learning, only 30 % of students reached the score above the KKM (Criteria of Minimum Competency). The conclusion of this research is that there is a relationship between language skills and chemistry learning outcomes. Learning chemistry in English has not given good results for students' learning outcomes. Therefore, the demands of learning in English need to be supported by good language skills to understand the learning content.

Keywords

Chemistry; English; Language skills; Learning outcomes

Full Text:

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