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Research Article

The effectiveness of content and language integrated learning-based teaching material in the topic of the nature of matter on scientific literacy

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Abstract

This study aimed to examine the effectiveness of teaching materials based on Content and Language Integrated Learning (CLIL) on scientific literacy on the topic of The Nature of Matter. Teaching material on this topic integrated the 4 pillars in CLIL, namely Content, Cognition, Communication and Culture. The Scientific Literacy Skills Scale (SLSS) measured in this study consisted of three aspects, namely explaining scientific phenomena, evaluating and designing scientific investigations, conducting data interpretation and scientific experiments. This study used an experimental method that was tested on 100 students in 3 schools that use English in chemistry learning. Student selection was done by purposive sampling. Data was collected through tests on students' scientific literacy and students' feedback questionnaires. The result of the analysis of N-Gain literacy percentage was 57%, it meant that this teaching material is quite effective in increasing student scientific literacy. Students' responses to teaching materials were in the very good category. From this study, it can be concluded that CLIL-based teaching material in the topic of the nature of matter is effective on students' scientific literacy.

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Introduction

The results of quality measurements of student's scientific literacy in Indonesia by the PISA (Program for International Student Assessment) in 2018 indicate that in general the scientific literacy scores of students in Indonesia are still below the average international literacy score (OECD, 2019). Indonesian scientific literacy score is 396, while international average is 489. The results of Indonesian scientific literacy are also below that of neighbor countries such as Malaysia with 438, Singapore with 551, and Brunei Darussalam with 431. This is certainly a great challenge for Indonesian education to find the right solution to improve the literacy of Indonesian students. Apart from the PISA results, many studies confirm that student literacy in Indonesia is still low (Ratini et al. 2018; Faisal & Martin, 2019). The problem of scientific literacy is a major obstacle in improving the quality of learning in Indonesia. Furthermore, El Islami et al. (2018) tell that literacy help people make a better live.

In line with the results of Indonesian scientific literacy in general, the results of scientific literacy, especially chemical literacy that have been examined in a preliminary study of this research in Cahaya Rancamaya High School, showed low results. The low scientific literacy, especially in the aspect of explaining scientific phenomena by 32%, evaluating and designing scientific investigations by 42.5%, and interpreting scientific data and experiments by 28.3%. An initial study of research conducted at the school which had demands for learning to use English as the language of instruction in chemistry subjects, found the fact that the low scientific literacy of students is caused by the low language skills of students, especially English. This causes students difficulty in learning teaching material

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which is also written in English. Language skills are needed to support the understanding of concepts so that they can improve scientific literacy.

One way to improve language skills, especially English, is to use these languages in learning (Brevik & Moe, 2012; Roiha & Sommier, 2018; Martínez Agudo, 2019; Deswila et al. 2020). Learning that integrates content and language in learning is known as Integrated Learning and Content Learning (CLIL) (Dalton-Puffer, 2011; Baneges, 2012; Dale & Tanner, 2012; Coyle et al. 2013). So, content and language are an inseparable unity. Language is not just an introduction to learning but also targets learned besides the content itself. At present CLIL has been widely implemented in Europe and some Asia such as Singapore, Malaysia and Hong Kong (Lin et al. 2019). This approach can have a positive impact on learning outcomes (Gulyas et al. 2015). Such positive impacts can for example increase interest (Lasagabaster & Sierra, 2009), motivation (Van de craen et al. 2007; Lasagabaster, 2019) conceptual knowledge (Zarobe & Zenotz, 2017; Huang, 2020), literacy reading (Admiraal et al. 2006; Prieto-Arranz et al. 2015). The above studies should be a reference for us, especially schools that implement bilingual programs to implement CLIL learning that has been proven to have a positive impact.

The positive impact is also expected to increase students' scientific literacy. It has already been mentioned that the initial findings indicate the low literacy of students in Cahaya Rancamaya High School. Therefore, this CLIL becomes a solution to the problem of low literacy of students in the school; it can even be a solution that is applied in Indonesia. Research by Lo et al. (2018) concluded that CLIL can increase student literacy. Morton (2020) further explains the positive relationship between content, language and literacy. While Coyle (2008) explained that CLIL consists of 4 pillars namely Content (the content of material), Cognition (thinking process), Communication (linguistics) and Culture. These pillars can improve the quality of learning, one of which is student scientific literacy.

Scientific Literacy on CLIL learning certainly requires a teaching material. The availability of teaching materials that are appropriate to the level of ability possessed by students becomes important (Mehisto, 2012). The role of teaching materials in learning cannot be denied (Vojíř & Rusek, 2019). Teaching materials have a key role in fostering scientific literacy, choosing strategies that are oriented towards science litration is a necessary way. But the facts on the ground show the lack of teaching materials. Ball (2018) says one of the biggest obstacles faced in CLIL implementation is the provision and design of teaching materials. Purnama et al. (2019), Vithanapathirana and Nettikumara (2020) explained the difficulty in finding learning resources in bilingual schools. These difficulties and challenges become the main foundation in this research.

In accordance with the findings of problems that have been found about the low literacy of chemical science due to low language skills and the lack of teaching materials suitable for students, the purpose of this study is to test CLIL-based chemical teaching materials that can improve student scientific literacy. The scientific literacy that will be investigated in relation to aspects of explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting data and scientific experiments. This aspect of scientific literacy is in line with PISA's findings that only 40% of students can reach level 2 and above. Level 2 indicates that students can recognize correct explanations related to general scientific phenomena, and use that knowledge to identify conclusions through the data provided.

Problem of Research

According to the background that has outlined, the research problem is examining the effectiveness of teaching materials based on Content and Language Integrated Learning (CLIL) on scientific literacy on the topic of The Nature of Matter. The research questions are as follows:

- Is there an effect of teaching materials based on Content and Language Integrated Learning (CLIL) on students's scientific literacy?
- Is there an effect of teaching materials based on Content and Language Integrated Learning (CLIL) on students's respond and interest in learning chemistry?

Method

Research Design

The research method used in this study is an experimental method that aims to produce and test the effectiveness of the products produced. The product is in the form of teaching materials based on Content and Language Integrated Learning (CLIL) on the topic of the nature of matter. These test questions are tested with one-group pretest-

posttest design technique, which measures the level of understanding (literacy) of students before and after learning (Fraenkel et al. 2012) with the schemes shown in Table 1.

Table 1.

The Scheme of the One Group Pretest-Posttest Design

Pretest	*Treatment*	*Posttest*
T_1	X	T_2

T1 as a pretest is done before students are given treatment; X as a treatment is given through the use of teaching materials produced; and T2 as a posttest is done after the sample is given treatment. With the One Group Pretest-Posttest Design, the treatment results can be known more accurately because it removes the bias from the research results

Participants

The subjects of this study were 100 students from 3 different schools. The school that was targeted by this study with different clusters is based on the similarity in the use of English in learning chemistry. There are 100 students in total; 40 students from Cahaya Rancamaya High School, 30 students from Kharisma Bangsa School, and 30 students from Depok Private School. Student selection is done by purposive sampling referring to Creswell (2012).

Data Collection Tools

Data is collected through tests to measure student scientific literacy and student feedback questionnaires.

Scientific Literacy Skills Scale (SLSS)

The test of student literacy is in the form of multiple-choice tests consisting of 25 questions and 4 choices in each question. The problem tests literacy on the topic of the nature of matter. This topic consists of 4 question indicators, namely state of matter, kinetic particle theory, changes of state, and diffusion. The 25 questions test literacy in the aspects of explaining scientific phenomena with a total of 6 questions, the aspect of evaluating and designing a scientific investigation of 9 questions, and the aspect of interpreting data and scientific experiments of 10 questions. Those aspects of literacy referring to OECD (2019). The test instrument used were tested for reliability with the method of Kuder Richardson (KR) 20 with a value 0.75 which means the instrument is reliable (Arikunto, 2017).

Data Analysis

Data analysis of test results uses points, where the correct answer of one question is given point 4, whereas if it is wrong it does not get points. Thus, the maximum value for this literacy result is 100 points.

To find out if there is a significant difference in the average between the results of the pretest and posttest literacy, it will be tested through paired sample t-test. This test is used for two samples or paired data. Paired sample t-test test was processed using SPSS version 23. The basis for the research decision is if the Sig. (2-tailed) $p < 0.05$, then there is a significant difference between the Literacy values in the pretest and posttest data. If the Sig. (2-tailed) $p > 0.05$, it means there is no significant difference between the literacy values in the pretest and posttest data. Paired sample t-test test is part of parametric statistics. Therefore, as a rule in parametric statistics, research data must be normally distributed.

Data normality was tested through the Kolmogorov Smirnov test with SPSS version 23. The normality test aims to determine whether the residual value (not on each of the research variables) is normally distributed or not. The interpretation of the Kolmogorov Smirnov normality test is as follows: If the significance value is in the Asymp column. Sig (2-tailed) or probability> 0.05, then the data is said to be normally distributed. In addition, the data will also be tested for data homogeneity. Homogeneity test (F) is a statistical test to find out whether or not the variances of two or more data distributions are the same. Homogeneity test used is Levene homogeneity test with SPSS version 23. The interpretation of homogeneity test results is as follows: If the significance value in the Sig column or probability> 0.05 then the data distribution is homogeneous.

Questionnaire is intended to determine student responses to teaching materials used. Student responses consist of responses to appearance, presentation of material and language used in teaching materials. The questionnaire is also used to determine students' interest in learning chemistry using English by using these teaching materials. The questionnaire was filled in using a Likert scale. Students put a checklist on each questionnaire indicator with guidelines 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. This questionnaire is filled out by

students at the end of learning. The results of the questionnaire were then converted into a percentage (%) and then classified as very good (80-100%) good (66-79%), sufficient (56-65%), not good (41-55%) and not good (<40%).

Procedure

CLIL Teaching materials are implemented for students in 3 meetings for 3 weeks. The first meeting discussed indicators of state of matter and kinetic particle theory, the second meeting discussed indicators of changes of state, and the third meeting discussed indicators of diffusion. Pretest is done before the implementation of CLIL teaching materials and posttest and student responses are done at the end of learning.

Figure 1.
Implementation of CLIL Teaching materials

Results

Teaching material developed to improve scientific literacy on the topic of the nature of matter uses the 4 pillars of CLIL, namely Content, Cognition, Communication and Culture. The specifications of these teaching materials and their effects on scientific literacy are explained in Table 2.

Table 2.
Specifications of CLIL-based Nature of Matter Teaching Materials

Aspects of Teaching Materials based on CLIL	Teaching Material Specifications	Effect on Literacy
Content (the content of material)	State of matter, kinetic particle theory, changes of state, and diffusion.	Increasing literacy through content or material that is closely related to everyday phenomena, from simple phenomena to abstract explanations.
Cognition (thinking process)	Distinguishing the form of matter and its properties, describing the kinetic theory of particles, identifying changes in the form of matter, and examining the process of diffusion.	Directing students towards the process of thinking about science phenomena, so students are able to build scientific explanations, interpret data, to conclude a scientific phenomenon.
Communication (linguistics)	Scientific terms, reading skills of scientific texts, expressing scientific ideas, and explaining the procedure of a scientific phenomenon.	Increasing scientific literacy through the acquisition of scientific language skills ranging from synthetic terms, to the ability to understand a science text.
Culture	Group discussion, respect for other people's ideas, interest in science, working in the lab according to the rules.	Improving scientific literacy through building scientific attitudes and character.

The effect of CLIL teaching materials on scientific literacy was measured through 25 multiple choice questions. The influence is seen by comparing the initial test scores (pretest) and final scores (posttest). The results obtained are explained in Table 3.

Table 3.
Analysis Result of Pretest and Posttest on Scientific Literacy of Topic the Nature of Matter

Implementation data	*Pretest*	*Posttest*
Total Students	100	100
Lowest score	20	40
Highest score	70	95
Average score	44,75	72,25
% N-Gain	57% (medium)	

Besides seeing the results of N-gain in general, an analysis of each literacy indicator tested is conducted. Indicator analysis of each issue of scientific literacy is important to know the ability of students to answer each indicator of scientific literacy. The following results are in table 4.

Table 4.
The Results of the Pretest and Posttest Analysis Per Indicator

Aspect of scientific literacy	Indicator	% N-Gain	Criteria
Explaining phenomena scientifically	Remembering and applying appropriate scientific knowledge	72	High
	Identifying, using and producing clear models and representations	40	Medium
	Making and justifying predictions appropriately	58	Medium
Designing and evaluating scientific investigations	Identifying scientific questions that can be explored through a given study	63	Medium
	Distinguishing questions that can be scientifically investigated	60	Medium
Interpret data and scientific evidence	Changing data from one representation to another	48	Medium
	Analyzing and interpreting the data, also drawing the right conclusions	75	High
	Identifying assumptions, evidence and reasoning in the text	65	Medium

The results of the pretest and posttest analysis per indicator show that the percentage of N-gain obtained is in the medium to high criteria. Table 3 shows the differences between the pretest results of students before getting treatment (average = 44.75) and posttest (average = 72.25), which means there is an increase in N-Gain by 57%. The N-Gain value is in the medium category (Hake, 1998). Comparison of pretest, posttest and N-Gain values is presented in Figure 1.

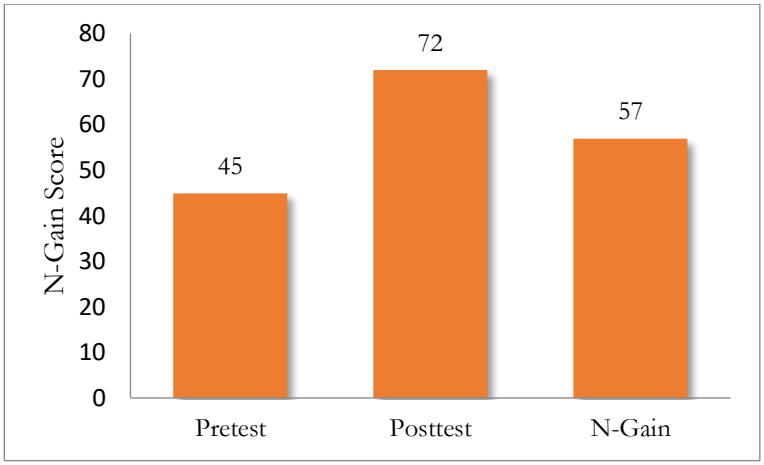

Figure 2.
Comparison of Pretest, Posttest and N-Gain

Data prerequisite tests consisting of the Normality and Homogeneity test were also carried out in this study. The results of normality and homogeneity tests on the scores of the pretest-posttest literacy are presented in Table 5.

Table 5.
The Results of Normality and Homogeneity Tests

Data	Sig. Value	Additional Information
Prestest - Posttest	Normality test = 0,701	Data is normally distributed
	Homogeneity tests =0,863	Data is homogeneous

After the prerequisite tests are carried out on normality and homogeneity, then the data is tested to determine the difference in values before and after learning with the Pair sample T-test, which is presented in Table 6.

Table 6.
Paired Sample T-test Results

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std.deviation	Std.error mean			
Pair Pre-post	27,500	11,528	2,578	10,668	99	0,000

In this table, the Sig. (2-tailed) = 0.00 means <0.05, so it can be concluded that there is a significant difference between the students' pretest and posttest scores after learning using CLIL-based chemistry teaching materials on the nature of matter topic.

After learning using CLIL-based chemical teaching materials, students are asked to provide a response or response to the teaching material. In addition, students are also asked to respond whether this teaching material can increase their interest in learning chemistry. The results of the student questionnaire analysis are shown in Figure 2.

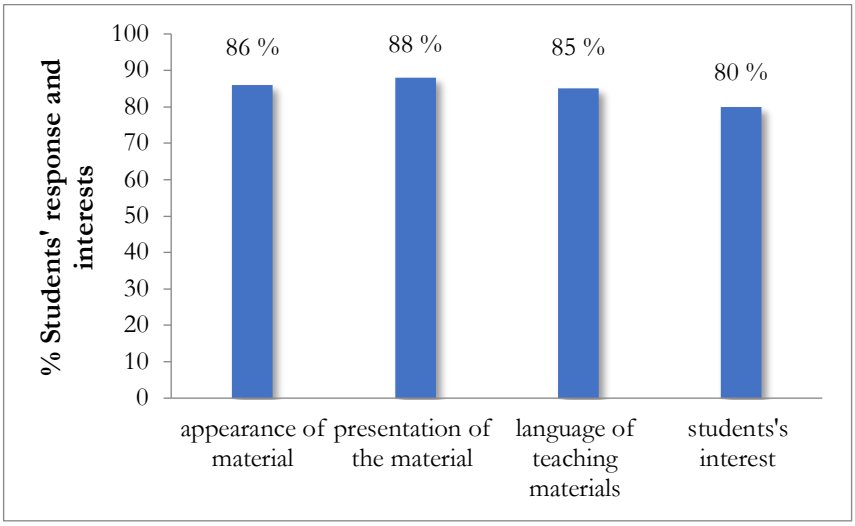

Figure 3.
Students' Response and Interests to Teaching Material

From the graph above, it appears that students' responses to the appearance, presentation of the material and language of teaching materials are in the very good category, which is above 80%. Likewise, an increase in interest of 80% is in the good category.

Discussion and Conclusion

CLIL-based teaching materials integrate science content and language that is used to improve student scientific literacy. Besides this teaching material integrates 4 pillars called 4C CLIL which consists of Content (the content of the material), Cognition (Thinking process), Communication (linguistics) and Culture. These four aspects distinguish this teaching material from other teaching materials as well as being the key in increasing students' scientific literacy.

The content chosen in this research is the nature of matter. The nature of matter is a fundamental and important topic in chemistry and is very contextual to everyday life. It is a fundamental aspect, in which there is a particle theory which is the basis of explanation for many topics such as atomic structure, bonds, molecules, chemical reactions, chemical equilibrium, and chemical energy (Harrison & Treagust, 2002). A good understanding of this topic is the key to understanding the next concept. Parmin et al. (2016) stated that science learning is presented integratedly because it relates to everyday life. Through this topic, during the learning process in this study, students have explained phenomena through observation, investigation and conclusion of things they often encounter. Not only the basic phenomenon, learning this topic found facts of learning that challenge students to think more abstractly by studying the behavior of particles of a substance when undergoing a change in form. The diffusion process described in this teaching material has also been shown to have an impact on students' understanding of the nature and characteristics of gases present in their environment.

In the cognition aspect of this CLIL teaching material, learning has been carried out through a series of scientific activities that direct students towards thinking processes of science phenomena, so students are able to build scientific explanations, interpret data, and conclude a scientific phenomenon. This teaching material has demanded students to be able to distinguish material forms and their properties, describe the kinetic theory of particles, identify changes in the form of matter, and examine the process of diffusion. These thinking activities can increase students' scientific literacy. This finding is reinforced by Coyle et al. (2013) who have found that the CLIL approach encourages students to use various cognitive skills in the use of target languages ranging from low ones such as understanding and remembering vocabulary to high cognitive skills such as creative thinking.

Communication aspects (linguistics) are proven to play an important role in increasing scientific literacy. This aspect enhances scientific literacy through the learning of language learning skills, for example understanding of scientific terms such as matter, solid, liquid, particle, volume, pressure; understanding of scientific processes such as melting, evaporation, freezing; use of scientific language to explain the nature and process of science such as solid has fixed shape, mercury is liquid at room temperature, gas particle move rapidly in all directions. This is in line with the findings of Heras and Lasagabaster (2015) about the effects of CLIL on improving learning vocabulary, and Várkuti's (2010) findings on the impact of CLIL on improving lexical language. In the end, the understanding of scientific language is able to bring students to understand a scientific text that explains various scientific phenomena

in everyday life. The ability to read is very important especially as one aspect of PISA literacy that is not yet entrenched in Indonesian society.

Culture increases the literacy of science through the development of scientific attitudes and character. This aspect is reflected in the material only reflected during the group discussion process, respecting other people's ideas, showing interest in science, working in the lab according to the rules and collaborative learning. Yamazaki (2019) writes that the purpose of CLIL lessons with collaborative learning is so that students can achieve competence to utilize content knowledge in their daily lives. Students are able to express their own ideas in creative ways based on the knowledge they have learned rather than just explaining the knowledge of the subject they are remembering.

This CLIL teaching material is proven effective in increasing students' scientific literacy that has been measured through knowledge tests. From the three aspects of science measured, namely explaining scientific phenomena, evaluating and designing scientific investigations, also interpreting data and scientific experiments, reinforced the results of the analysis of N-Gain values in this study which reinforces that teaching materials are effective for student scientific literacy. The specifications of teaching materials used in this study using operational languages encourage students to want to read texts. Integrating examples of science ideas that are integrated with the presentation of material provides new experiences for students because of contextual learning resources. The various scientific procedures explained in teaching materials about science phenomena have given students confidence about the importance of a process in learning science.

The aspect of scientific literacy explaining scientific phenomena is increasing. This can be seen from each literacy indicator that has moderate to high N-Gain. The teaching materials of the nature of matter explain a lot of scientific phenomena that exist in our daily environment. Through this teaching material, for example students are required to be able to explain the process of freezing, melting, yawning using particle theory; explain the phenomenon of the diffusion process, and so on. The literacy aspect of evaluating and designing scientific investigations also increased. This teaching material has features that facilitate students to explore and investigate scientific phenomena, for example in answering questions about ice, water and water vapor that have the same formula but what makes these substances different. The aspect of interpreting data and scientific experiments is enhanced by for example students conducting experiments on gas pressure, what happens if the gas is heated and the volume is reduced. Students are also required to interpret data, for example, data on boiling and melting points, interpretation of data on the molecular mass of a gas in relation to the speed of diffusion.

CLIL-based teaching materials on the topic of the nature of matter are effective in increasing student scientific literacy with the achievement of N-Gain literacy by 57%. The four aspects of CLIL that exist in this teaching material are Content, Cognition, Communication and Culture proved to be able to significantly increase literacy scores measured by pretest and posttest. The significance can be seen by Sig. (2-tailed) = 0.00 less than 0.05 which means very significant. From the value of student responses to teaching materials is very positive, and student interest in learning chemistry increases.

Recommendations

Recommendation for applicants to implement and create CLIL based material. Considering the importance of mastering English as an international language, especially in this era of globalization, learning English is not enough to be learned in English subjects only. English needs to be integrated and used directly in lessons like science, this is what is called the dual focus in the CLIL approach.

CLIL-based teaching materials effectively improve students' scientific literacy and language skills. Therefore recommendation for further studies are necessary to study and analyze the effect of CLIL teaching materials on other things such as creativity, science process skills and so on.

Limitations of Study

Some data in this study were taken online because of the covid-19 pandemic. Therefore some students' answers may be less valid due to dishonesty in answering the questions given.

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