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The Integration of a Flipped Classroom, and Brain-Based Learning, and its Effect on Students' Critical Thinking Skills in Chemistry

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This study aims to determine the effect of applying a flipped classroom, and brain-based learning model on students' critical thinking skills in chemistry. The research employed a true experiment method with a posttest-only control group design. Seventy Grade 11 students comprised the sample. The students' critical thinking skills were assessed using five indicators adopted from the Valid Assessment of Learning in Undergraduate Education (VALUE) rubric of the Association of American Colleges and Universities. The results showed that the average result of the critical thinking skills of the experimental group was higher than the control group. Based on the t-test at the significance level of $\alpha = 0.05$, there were significant differences between the two groups. The integration of a flipped classroom with a brain-based learning model in the experimental class provided a different learning experience, and optimised the learning inside, and outside of the classroom. This learning model increases students' learning readiness, provides comfort in learning, maximises the performance of the left and right brain simultaneously, and develops students' critical thinking skills.

Key words: *Flipped classroom, Brain-based learning, Critical thinking skills.*

Introduction

The implementation of the 2013 Curriculum in Indonesia currently facilitates student-centered learning, where the teacher acts as a facilitator. Students are not only receiving knowledge passively, but they are also required to collect their information under the guidance of the teacher actively. Students have to be able to connect and relate new information with the knowledge they already have and apply it to solve the problem at hand. The development of student competencies is directed according to twenty-first century competencies, one of which is the ability to think critically (P21, 2009). The goal of school education in the twenty-first century is to prepare students to have a deep understanding of knowledge, as well as twenty-first century competencies and skills, such as critical thinking skills to match the challenges in society (Kong, 2015).

The results of observations on chemistry learning show that not all students are actively involved in student-centered learning due to ineffective application, and less varied learning models. This is reflected by the lack of students' enthusiasm in the learning process. Students look passive in class, they do not pay attention to the teacher, and lack the motivation to learn. This will have an impact on the low learning outcomes, and students' critical thinking skills.

Many have researched an array efforts to develop students' critical thinking skills, some of which state that the application of brain-based learning makes the learning process more enjoyable, interesting, and encourages students to remember, and express ideas that ultimately enhance critical thinking skills (Wulandari, 2014; Prasetya & Hadisaputro, 2013). The brain-based learning model can also improve students' intelligence in thinking because the learning process is done by optimising the performance of the brain, which can contribute to improving learning outcomes (Purnama, Solfarina, & Ratman, 2015). The brain-based learning model provides learning concepts that are oriented towards the empowerment of the brain potential of students (Yulvinamaesari, 2014). In this learning model, students will learn to balance the two functions of the brain: the right brain, and the left brain. In fact, chemistry learning in schools tends to focus on the performance of the left brain, which is related to logical thinking, such as linking facts with concepts, discussing in groups, and others. It can be maximised through balance with the right brain-related non-verbal processes, such as the use of music, making concept maps, and composing the practicum (Sadiqin, Istadji, & Winarti, 2017).

In the brain-based learning model, the teacher must be able to create activities that are varied, fun, and interesting, so that it will create student activity. To apply the brain-based learning model, it requires more time, a variety of media, and students' readiness to learn. Learners find it difficult to accept learning well if they do not have the readiness to learn in class. The flipped classroom learning model can be used to overcome time constraints, and improve student learning readiness. The flipped classroom is a learning model that minimises instruction when teaching by utilising technology in providing subject matter for students to study outside the classroom. Students learn a new material independently (at home) through reading or watching learning videos, and then the material is discussed in the classroom

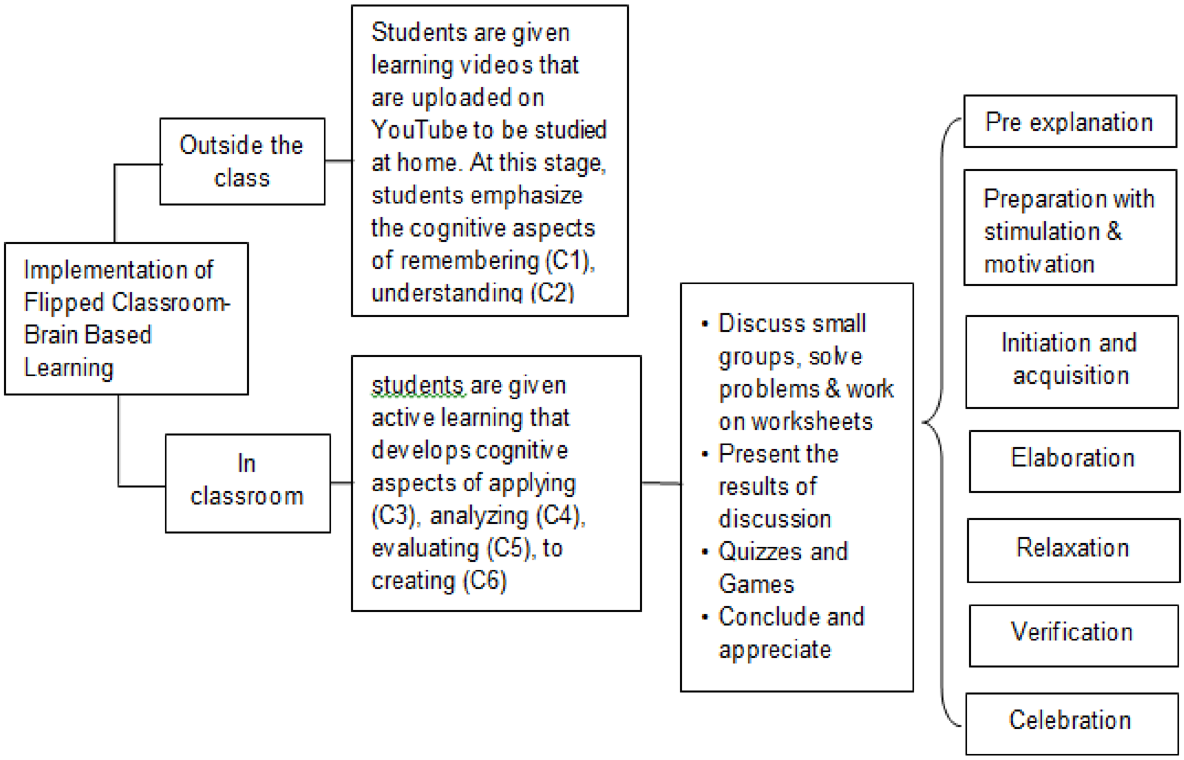
(Bergmann & Sams, 2012; Al-Shammari, 2019). The use of learning videos help students to work on assignments, strengthen concepts, undertake test preparation, clarification, and support problem-solving in the classroom to increase student activity (Schultz, Duffield, Rasmussen, & Wageman, 2014; Smith, 2013). Besides, flipped classrooms have an impact on students' deeper understanding, developing higher-level thinking skills, and student learning outcomes (Danker, 2015; Paristiowati, Cahyana, & Irsa S. B., 2019). DeRuisseau (2016), in his research, states the use of a flipped classroom learning model gives students more time in class, and thus, it can be used to train students' critical thinking skills.

Research on the positive effects of both learning models — the flipped classroom, and brain-based learning — has been done, but no research integrates these two models in chemistry learning to improve critical thinking skills. By considering the advantages of the two learning models, the integration of the flipped classroom learning model with the brain-based learning model is carried out in this study. The integration of a flipped classroom, and brain-based learning will optimise the development of students' critical thinking skills. In the integration of this model, students are given a learning video to watch outside the classroom to understand the concept of the teaching material. Learning videos are provided as homework, so that students have a readiness to learn. Moreover, the learning activities in the classroom use active learning through brain-based learning models.

Methodology

This research was conducted with quantitative methods, using the true experiment approach with a posttest-only control group design. This research was conducted at Grade X with a sample of 70 students determined by a cluster random sampling. The two classes were given a different learning model but with equal student abilities. The control class uses active learning, which is based on the 2013 Curriculum. Meanwhile, the experimental class uses the integration of the flipped classroom, and brain-based learning model. The topic of ‘oxidation reduction’ (redox) is issued with the same time span of four meetings, and with a duration of three hours of study per meeting. The stages of the learning implementation are presented in Figure 1.

Figure 1. Stages of learning implementation



The instrument used in this study was a critical thinking skills test with a rubric that refers to the VALUE rubrics of the Association of American Colleges and Universities. Specifically, explaining a problem, proving the concept, influence of a context, provide a response or perspective, and provide a conclusion (Gleason et al., 2013). The hypothesis testing was completed using a t-test with a significance level of 0.05.

Results and Discussion

The results of the study showed that the posttest means value of critical thinking skills in the experimental class was higher than the control class. The mean value of the experimental class was 76.63, with the lowest value 50, and the highest value 96. Meanwhile, the mean value of the control class was 54.83, with the lowest value 25, and the highest value 83. The results of the analysis of students' critical thinking skills on each indicator are presented in Table 1.

Table 1: Analysis of critical thinking skills of all indicators

Indicator	**Experiment class**	**Control class**
Explain a question	73.6%	62.9%
Prove the concept	72.1%	48.9%
Influence of a context	77.1%	62.1%
Give a response or perspective	77.9%	58.6%
Give a conclusion	86.4%	47.1%

Based on Table 1, it can be seen that the average value of the experimental class in each indicator is higher than the control class. This means that the students' critical thinking skills can be improved if the learning process is carried out correctly. The hypothesis test results were completed through two independent sample t-tests with a significance level of $\alpha = 0.05$, using SPSS 25, which can be seen in Table 2 below.

Table 2: Result of t-test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means	t-test for Equality of Means					
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning outcome	Equal variances assumed	1.326	0.253	6.507	68	0.000	21.8000	3.35005	15.11509	28.48491
	Equal variances not assumed			6.507	66.231	0.000	21.8000	3.35005	15.11185	28.48815

Based on Table 2, it is known that the Sig. Levene's Test for the equality of variance is 0.253> 0.05. Therefore, it can be said that the variance of both groups is homogeneous. The significant value of two-tailed is less than 0.05, which indicates that H_0 is rejected, and H_1 is accepted. It can be concluded that there is a significant difference in the average learning outcomes of the experimental class, and the control class.

The difference in the average results of critical thinking skills between the control class, and the experimental class proves that the use of the integrated learning models of a flipped classroom, and brain-based learning is effectively applied to chemistry learning. The learning with a flipped classroom model allows students to learn outside the classroom, using learning videos that can be played repeatedly, so that students can capture the lessons at their own pace. The results of the study by Schultz et al. (2014) stated that the flipped classroom learning model allows students to pause, rewind, and repeat videos, and be able to learn at the speed of their understanding. The use of learning videos outside the classroom can also increase students' learning readiness, so that students can be more active, confident, and motivated in learning. This can happen because students have gained the knowledge and understanding of concepts before learning in the classroom, and are already familiar with the learning objectives. The results of this study are in line with the statement of Ceylaner and Karakuş (2018), that the flipped classroom learning model has a positive impact on students' self-readiness, increases interaction between students, and between students and teachers, and positively impacts the attitude of responsibility. The flipped classroom is also a learning model that has been proven to increase students' motivation and self-confidence during the learning process in the classroom (Paristiowati, Fitriani, & Aldi, 2017). The activities of students, in the classroom, can be filled with tasks that require problem-solving, hypotheses, experiments, exploration, making a product, implementing, and communicating related to the material being studied (Flores, Silva, & Del-Arco, 2016). Thus, students' critical thinking skills can be developed through the learning process in the classroom.

In this study, the learning process in the classroom through a brain-based learning model creates learning which is more enjoyable, meaningful, easy to understand, and is memorable in students' memories because it includes everyday experiences, and uses music. The application of brain-based learning models has proven to be effective in ensuring students' brains work optimally, and positively influencing students' success (Saleh, 2012). In the brain-based learning model, there are several stages which are different from other learning models. Therefore, it has its advantages, such as the implementation of a brain gym, meeting water needs during the learning process, and good air circulation, which is beneficial for the brain, so students can more easily absorb the information. The brain gym is a series of simple body movement-based exercises that can be performed before or during learning to maximise brain performance, as well as maintain brain health, and comfort (Dennison, 2008; Jensen, 2011). Another advantage is that students are given time to relax and repeat the material that has been learned through the deepening of the material.

The integration of the flipped classroom model with brain-based learning makes the deepening of the material run well because students already have the readiness to learn by watching the previous video. At this stage, students work on assignments, reinforce concepts, work on tests, or practise questions through games, clarification, experiment, and discuss problem solving in the class properly. Some of the students' tasks include making songs in a group linked to redox material. The students are expected to develop creativity and simplify the pattern or connection between the new information and obtained information, so it can be embedded in the memory of students. This is in line with McCammon's research (2008), which shows that by creating and analysing songs in science learning, it increases student motivation, and learning enthusiasm. In addition, creating songs with science content is a quality learning experience, in that it can increase science knowledge, increase understanding of students' concepts, and have an impact on student creativity (Crowther, 2017; Governor, Hall, & Jackson, 2013). According to Crowther's (2012) research, music, where lyrics contain material content, will have an impact on learning. The impact is that students can recall previous taught concepts and can easily remember the keywords of the learning concept. All activities in the class are carried out in a relaxed and conducive atmosphere according to principles in brain-based learning. In addition, a comfortable and conducive environment make students more focussed to receive learning material, feel happier, and provide solutions or suggestions to solve the problem at hand (Wulandari, 2014). When learning is conducted in a relaxed, meaningful, and active manner, the brain will work optimally as the result of students feeling more comfortable, and motivated in the classroom (Kumala, Firdayani, & Hudha, 2018).

Besides, the integration of the flipped classroom, and brain-based learning also provides a different learning experience, optimising learning outside the classroom, and in the classroom. Students carry out independent learning activities outside the classroom, under the guidance of the teacher through learning videos that have been designed. These activities are limited to the knowledge and understanding of concepts and facts in the material 'oxidation reduction' (redox) that is learned before in class. In the classroom, the teacher acts as a facilitator to motivate, guide, and provide feedback on student performance. When the students face difficulties in learning, they can ask the teacher or discuss in a small group, in an effort for students to gain a better understanding. The teacher allocates time for students who need help to improve the material which cannot be learned on their own.

Based on the description above, the use of a flipped classroom model has a positive influence on learning. Moreover, it is also integrated with a brain-based learning model that can enhance a positive influence on redox learning by making the condition of learners more active, more relaxed, and more interested in learning. The integration of a flipped classroom, and brain-based learning makes learning innovative because the learning time in the flipped classroom can be used to improve the teacher's interaction with students, encourage creativity, enable new ways of critical thinking, and problem-solving (Roehl et al., 2013). Meanwhile, the brain-based learning creates a positive learning environment at a high level of learning, learning retention, and attitude (Tüfekçi & Demirel, 2009).

Conclusions

Based on the results of research and data analysis, it can be concluded that the application of an integrated flipped classroom, and brain-based learning has a positive influence on students' critical thinking skills in chemistry, especially on redox material. The application of the flipped classroom, and brain-based learning integration model provides a different learning experience, and optimises learning inside and outside the classroom. This can increase the readiness of learning in class, provide comfort in learning, and maximise the performance of the left brain, and right brain simultaneously, so that students become more active and can hone students' critical thinking skills.

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