

The Effect of Flipped Classroom and Problem Based Learning Strategies in High School Chemistry Education

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Abstract

Thermochemistry and Reaction Rate are the subjects with the lowest achievement level at the National Exam (UN) in 2016. Thermochemistry and Reaction Rate are subjects that require algorithmic abilities in addition to factual and conceptual knowledge. The purpose of this research is to know the influence of learning strategies of flipped classroom and problem-based learning on Thermochemical and Reaction Rate learning results. This research uses quantitative approach using experimental method with 3x2 treatment by level design, chemistry learning results as dependent variable, learning strategy as independent variable, self learning as moderate variable. Before further testing the variable with ANAVA two way, they first get tested with normality and homogeneity test to research data. The result of this study can be seen that the strategy of flipped classroom, problem-based learning, and expository influence student's chemical learning results. Achievement of learning results with flipped classroom learning strategy is higher than the problem-based learning and expository strategies. There is a significant interaction between the learning strategy and the student's self learning on the use of problem-based learning and expository strategies.

Keywords: Flipped classroom; Learning strategy; Thermochemistry and reaction rate learning results; Algorithmic.



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1. Introduction

The achievement of the chemistry learning results in the National Exam 2016 at thermochemistry is only 27% and reaction rate is 31%, meaning that 73% of students are unable to solve the thermochemistry problem, and 69% of students are unable to solve the reaction rate problem. This is a big question for chemistry teachers. What's wrong with thermochemistry and reaction rate subject? Are they so hard? From the results of the questionnaire obtained that students feel difficult when solving algorithmic problems in thermochemistry and reaction rate in a limited time. It takes learning strategy that can strengthen the ability of procedural capability based on calculation (algorithmic), besides factual and conceptual knowledge. Several previous studies have concluded that incorporating technology into learning can improve students learning results (Lo and Kew, 2017) (Arnold-Garza and Tomlinson, 2017). One learning strategy that uses IT in learning is the flipped classroom learning strategy, which is a learning strategy that involves students actively, learning independently through media like video before entering the classroom, the class is used to interact actively to solve difficult problems Ngee (2017). The researchers will compare the flipped classroom strategy with the problem-based learning (PBL) strategy, which is currently recommended for use in K-13, besides discovery learning and project based learning. Several studies have shown that PBL strategies have succeeded in improving conceptual knowledge, critical thinking skills, higher learning abilities that ultimately improve learning results (Loyens, 2014); However, a study linked to flipped classroom learning strategies with procedural capabilities based on calculations (algorithmic) has never been done. Internal factors of students, a self learning abilities is expected to be very influential on the learning process in flipped classroom and problem-based learning, therefore the researcher makes self learning as moderate variable. This study will compare the influence of flipped classroom learning and problem-based learning strategy by considering student's self learning on chemistry learning results.

2. Literature Review

Algorithmic is a sequence of logical steps to solve a systematically arranged problem based on computation. Based on the facts that happen in school, students took longer to understand computational-based learning materials, compared to other learning materials that only required factual, conceptual, and procedural abilities that were not calculation-based. To resolve this problem, there is needed a learning strategy that can solve time limitation problem and improve student's algorithmic abilities. While the main goal of flipped classroom strategy is to provide students with self-focused learning environment in solving problems (Balan *et al.*, 2016), the teacher retains control over

student learning activities (Bergmann *et al.*, 2016). Flipped classroom is described as a learning model that combines direct learning with constructivist learning experiences, students are required to build their new knowledge based on the experience students receives independently (Smaldino *et al.*, 2014). In addition, the flipped classroom also proved to be effective for large classes, raising the student's positive perceptions of the learning process and improving learning results (Beatty and Albert, 2016; Persky *et al.*, 2017) Flipped classroom can also increase teacher / lecturer satisfaction in addition to improving student's perceptions and quality learning process (Flores *et al.*, 2016; Unal, 2017). In an analysis of flipped classroom from 2013 until 2015, it is said that flipped classroom has a positive impact on students; motivation to get achievement, interaction, and also a study that calculates the suitability of the classroom and quality of the video used (Yang *et al.*, 2015; Zainuddin *et al.*, 2016). Research on the flipped classroom strategy in chemistry, considered an effective strategy to be used in higher education (Seery, 2016).

There is a relieving statement to the teachers, "There is no significant challenge in the application of flipped classroom" (Lo and Kew, 2017). However, there are studies that stated the failure to apply the flipped classroom strategy, due to student's inability to e-learning processes that are not monitored by the teachers, lack of computer skills and technology by teachers Li (2018). Based on the results of this study, researchers assume that the flipped classroom learning strategy can be used in chemistry learning especially on thermochemistry and reaction rate subject. In addition to flipped classroom learning strategy, problem-based learning (PBL) is widely used strategy in science learning process, which is one of the strategies recommended in K-13 besides discovery learning and project based learning strategy. PBL can significantly enhance student's creative idea through open-ended learning in the problem solving process (Ulger, 2018).

In the problem-based learning strategy implementation, it was found that there was no difference in contribution between male and female student interaction in practicing problem solving (Hirshfield and Koretsky, 2017). In a practical research that PBL strategy makes the study group more active and initiative in discussions and interactions, and finds appropriate article referrals, has good analysis in handling a case, and easily finds the best students in the group (Chounta *et al.*, 2017; Ju, 2017; Lei *et al.*, 2016). In a PBL based courses show superior and effective learning skills compared to those instructed using traditional approaches (Alrahlah, 2016). Other studies have concluded the relative effectiveness of PBL for retention as well as its function in the application of knowledge, and influencing the student learning results (Downing *et al.*, 2011). There is also a study that concludes that Problem Based Learning is a traditional educational tool, but its broad application can be manifested in leadership training (Yeo and Yeo, 2016). Problem Based Learning is an active student-centered learning strategy by relying on a collaborative problem-solving process. Several previous PBL studies have not been done on materials containing problem solving that including an algorithmic calculations. The research that has been done on enthalpy reactions materials says that with the problem based learning strategy, comprehension of the enthalpy concept increased significantly, the student's positive attitude towards laboratory activities also increased (Gurses *et al.*, 2015). Therefore this study tries to compare the influence of flipped classroom and PBL strategy as experimental class, and one control class using expository strategy. Expository learning can be defined as a systematic learning process, which teachers using verbal to deliver the materials to the students. In an article described the pattern of interaction dominated by teachers in the process of expository learning will lead students to maintain their passive attitude (Speizman and Linda, 2011). As a result, students fail in creating problem solving patterns in their learning. This condition is different from the two-way learning process (active students) as in the learning process of flipped classroom and problem based learning. However, there are still many teachers in the field using expository theory because it is considered easier and does not provide a heavy and complicated burden on teachers, in addition to the limited facilities to use in flipped classroom and problem based learning strategy. Learning strategies have an important role in influencing in learning and the results. However, the internal factors of the students can also effect the success of the learning process and the students's own learning results. Factor that allegedly influence is the student's self learning, which in this study is a moderate variable.

3. Methodology/Materials

This research was done by using experimental method with treatment design by level 3x2 in grade XI student of science program at SMAN 1 Setu Bekasi. The study was done on chemistry subjects with 17 meeting with thermochemistry and reaction rate subject. The study was done by comparing two experimental classes, one study class with a flipped classroom strategy, one learning class with a problem-based learning strategy and one control class that using expository learning strategy. The result of chemistry class as dependent variable, learning strategy as independent variable, and self learning as moderate variable. The research begins with spreading questionnaires to student as analysis of their needs, followed by making learning instrument of chemistry class and self learning, learning implementation plan (RPP), learning media in video form that will be used the first experimental class that is using flipped classroom strategy, making problem scenario for class that using problem based learning strategy, target population in this research is all students of class XI science program in Bekasi Regency, while its reachable population is all students of class XI science program in SMAN 1 Setu of Bekasi Regency. Research samples were taken randomly from the five existing classes of science courses, one for the class of flipped classroom, one for PBL class, one for the expository class. Each students in each class stayed 27% of 45 students, that is students who have high self learning (12 students), and 27% of students that have low self learning (12 students) and similarly for PBL and expository classes, sample research is divided into six cells.

All instruments are tested for validity and reliability before being used in research, firstly tested to grade XII students who have studied thermochemistry and reaction rate. The research data were tested with normality test

using Kolmogorof Smirnov and homogeneity test using Bartlett Test with $\alpha = 0.05$ significance level. The results of normality test in this research from all group of $A_1, A_2, A_3, B_{1,1}, B_2, A_1B_1, A_2B_1, A_3B_1, A_1B_2, A_2B_2, A_3B_2$ and all group are stated normal, with Sig value > 0.05 . Accept H_0 . Homogeneity test using Bartlett Test to all groups with Sig Value > 0.05 , it means all population in all group have same variance, then hypotesis test with Two Lane ANOVA with results as follow:

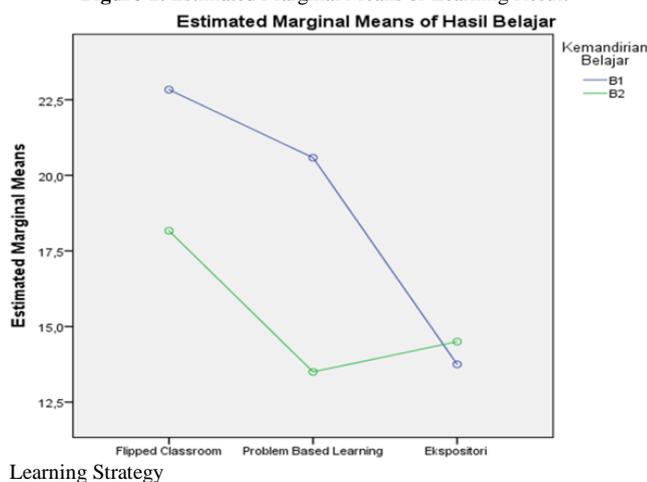
Table-1. ANAVA Two Lane Calculation Results of Chemistry Learning Results

Varians Source	JK	db	RJK	F_0	F_{table} $\alpha=0,05$
Between A	489	2	244,5	13,375	3,13
Between B	242	1	242	13,238	3,98
Interaction of AB	192	2	96	5,251	3,13
Inside	1.206,5	66	18,28		
Total		71			

Explanation:
 Db: Free Degree
 JK : Sum of Squares
 RJK: Average from Sum of Squares

Tests of Between-Subjects Effects					
Dependent Variable: Learning Result					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	923,944 ^a	5	184,789	10,109	,000
Intercept	21355,556	1	21355,556	1168,228	,000
Strategy	488,861	2	244,431	13,371	,000
Self Learning	242,000	1	242,000	13,238	,001
Strategy * Self Learning	193,083	2	96,542	5,281	,007
Error	1206,500	66	18,280		
Total	23486,000	72			
Corrected Total	2130,444	71			

Figure-1. Estimated Marginal Means of Learning Result



Based on the hypothesis of the test result table above shows that Main effect: First, at Inter A varian source shows $F_{0(A)} = 13.375$ and $F_{table} = 3.23$ with significance level $\alpha = 0.05$ where $F_{0(A)} > F_{table}$, or reject H_0 . Therefore, there is a significant difference in the mean of student’s chemistry learning results between flipped classroom strategy (A1), problem based learning (A2), and expository (A3). Second, the variance source of Inter B show $F_{0(B)} = 13.328$ and $F_{table} = 3.98$ at significance level $\alpha=0.05$ where $F_{0(B)} > F_{table}$ that means reject H_0 and accept H_1 . Thus there are differences in average learning results between students who have high self learning (B1) and students who have low self learning (B2). Meanwhile, for the interaction effect at interaction AxB varians source, there is significantly interaction between learning strategy (A) and self learning (B) which proved by value of $F_{0(AB)} = 5.251$ and $F_{table} = 3.13$ where $F_0 > F_{table}$ at significance level $\alpha = 0,05$ so that H_0 rejected dan accept H_1 .

Based on the interaction effect hypothesis result is significant, as shown in the graph above, student who have low self learning will get higher learning result if compared with students who have high self learning if the students learning using expository strategy. Next, researcher do simple effect test. Before testing the differences from six categories / groups, researcher tested the average difference from the six groups with One Way ANOVA with following hypothesis:

$$H_0 : \mu_{11} = \mu_{12} = \mu_{13} = \mu_{21} = \mu_{22} = \mu_{23}$$

$$H_1 : \text{at least one symbols not the same}$$

From two way ANOVA, the result of average difference between groups is $F_0 = 10.09 > F_{\text{table } (0,05;5;66)} = 2,36$, so $F_0 > F_{\text{tab}}$ means H_0 rejected. Thus it can be said that there is an average difference between the six group of A_1B_1 , A_1B_2 , A_1B_3 , A_1B_2, A_2B_2 , A_2B_2 , A_3B_2 .

There is the result of whole testing hypothesis:

- There is influence of learning strategy of flipped classroom, problem based learning, and expository strategy to student's chemistry learning results.
- The learning chemistry learning results of students who learn with flipped classroom learning strategy is higher than students who learn with problem-based learning strategy.
- Chemistry learning result of student with flipped classroom learning strategies are higher than student that learning using expository strategy.
- Chemistry learning result of student who learn with problem based learning is higher than the students learning with expository strategy.
- There is an interaction effect between learning strategy and self learning on student's chemistry learning results.
- Chemistry learning result of students learn with flipped classroom strategy are not higher than students who learn with problem based learning strategy in student who have high self learning.
- Chemistry learning result of students with flipped classroom strategy are higher than students who learn with problem based learning strategy in student who have low self learning.
- Chemistry learning results of student using problem based learning strategy are higher than students who learn with expository learning strategy in student who have high self learning.
- Chemistry learning results of student using problem based learning strategy are lower than students who learn with expository learning strategy in student who have low self learning.
- Chemistry learning results of student using flipped classroom strategy are lower than students who learn with expository learning strategy in student who have low self learning.

Chemistry learning results of student using problem based learning strategy are lower than students who learn with expository learning strategy in student who have high self learning.

4. Results and Findings

Based on the differential analysis result with ANAVA Two Path in table 1 at inter A variance source show $F_{0(A)} = 13.375$ dan $F_{\text{table}} = 3.13$ with significance level $\alpha = 0,05$, it means $F_{0(A)} > F_{\text{tabel}}$ so that reject H_0 , this shows that there are differences in average score of student's chemistry learning result with flipped classroom, problem based learning, and expository learning strategy. This means that this study empirically proves that different strategies can impact on differences in learning result.

Based on the result of Jalal Nouri's research entitled "The Flipped Classroom for active, effective and increasing learning- especially for low achievers (Jalal, 2016) that the learning strategy of flipped classroom can improve student's learning activity and at the same time improve student learning results in both high and low ability students. This means that mostly flipped classroom learning strategy is proven to improve student learning results, both high ability and low ability students. Similarly, the implementation of PBL strategy can improve argumentation and problem solving (Lo and Kew, 2017). The subject of enthalpy can increase student's academic ability with problem based learning strategy (Ahmet Gurses), this proves that this research strengthens the previous studies, both of which can improve student's activity in the learning process and also have the opportunity to improve student competence on different side. This result make a different learning results.

Highest student chemistry learning result is obtained by flipped classroom class, followed by problem based learning class, then the lowest is expository class. Why is the flipped classroom strategy superior to PBL strategies in thermochemistry and reaction rate? It has been mentioned previously that the material contained in the thermochemistry and reaction rate requires procedural capabilities based on algorithmic calculation, which need more time to understand all of the materials, besides basic mathematical skills students must have. Flipped classroom facilitates students to understand factual and conceptual material independently outside the classroom, and the time in the classroom is used to practice completing procedural algorithmic-based material actively accompanied by the teacher. Meanwhile in PBL strategy, time in the classroom is used to solve all problems from factual, conceptual problems, and practice a bit of procedural problem based on algorithmic calculations, while the next practice is done independly by students outside the classroom. While in the Nasional Exam (UN) and daily test question, percentage of questions in the form of algorithmic appear more than the question with conceptual form.

Beside, there are interesting thing from the results of this study that is in students who have high self learning and learning results of students who learn with strategy of flipped classroom and problem based learning differentially is not significantly different, although descriptively there is a different that the result of both of the strategy have the same learning results (6th hypothesis analysis result). It can be explained that students who have high self learning, can overcome its limited study time in the classroom so that it can still solve the learning problem as well. As described in the study results, "Can Self Directed Learning Environment Improve Quality of Life?" Kovalenko and Smirnova (2015); Noorriati *et al.* (2015) students who have high self learning, are individuals who highly initiative, with or without the help of others in meeting their learning needs. They can identify learning resources for learning needs, implement the most suitable learning strategies for himself and able to evaluate the process and learning result. This becomes one of the foundation, for the high learning results of students who have high self learning who learn with problem-based learning. Students who have high self learning will be able to solve their learning problems in a way that suits what they want. This means for students who have high self learning,

flipped classroom and problem based learning strategies have almost the same opportunities to be used. To the teachers / educators can determine the choice based on the availability of facilities that support the implementation of the two alternative strategies above; flipped classroom or problem-based learning. While for expository strategies for materials similar to Thermochemistry and reaction rate, it is not recommended, because it proved less effective in improving student learning results. Alternative for teachers who want to use the flipped classroom strategy, without creating their own learning videos, can search for videos that are widely available in reputable media links for use as self-directed student referrals. In the era of the current technology for urban areas, where the Internet network can be accessed easily, then the flipped classroom strategy is very possible to use. As for the problem-based learning strategy can be used if there is adequate laboratory, without overriding the characteristics of students. The implementation of the strategy of problem-based learning in chemistry is proven to improve the students' skills in experimenting in the laboratory as well as increasing students' understanding of what they learn (Chopra *et al.*, 2016). That is, if the learning objectives are improving students' skills in experimenting and conceptual understanding without algorithmic based calculation then the problem-based learning will be effectively used in learning.

The results of the 9th hypothesis analysis, the results of student learning with flipped classroom learning strategy was still higher than the results of student learning with problem-based learning strategies in students who have low self learning. This shows that the flipped classroom learning strategy can improve student learning results in students who have high learning ability and students who have low self learning. Students with low self learning require an outside stimulus to provide proper spirit and direction in the learning process. Open the opportunity to listen to the video, open means time and duration depends on the opportunity owned by students, binding means there are tasks that must be completed by the students during self-study, will increase the spirit of student learning. Because at the time of entry into the classroom students have possessed a light basic knowledge (C1 - C3) that can be a provision and confidence of students when entering the classroom. Students will have a positive perception of the learning process, in addition students learn by accompanied by teachers and other friends who have more ability, when solving complex problems / problems. so that when students have difficulties, can directly request the help of teachers or other friends. This means that in the process of learning flipped classroom no repetitive problems and settles on a student in a long time, this can reduce the burden of student learning, but will provide encouragement to students who lack the ability though. In contrast to students learning with problem-based learning strategies, he practiced solving complex problems, including algorithmic calculations, outside the classroom without accompaniment by highly skilled teachers and peers. As a result, when students who have low self learning, where he has a high dependence on others in completing the learning process, will find it difficult to solve problems, especially algorithmic problems. This difficulty will be frustrating to the students concerned, even can lead to apathy towards the lesson. It can be said that flipped classroom is effective for students who have high or low self learning, whereas PBL is only effective for students who have high self learning. The independence of learning related to the student's academic personality and achievement meaning that the higher the students' self learning the higher the achievement of the learning he achieved.

In students who have low self learning, the expository learning strategy is more effective than the problem-based learning strategy. In learning with expository strategies students just wait and receive what will be given by teachers while in the classroom, students are passive and are teacher center. As Nance Speizman says in his article "The interaction patterns dominated by teachers in the learning process will lead the students to maintain their passive attitude. As a result students fail to create problem solving patterns in their learning, (Speizman and Linda, 2011) So that students who have low independence is not appropriate if learned with problem-based learning strategy learning, but more appropriate with expository learning. They are more comfortable and less depressed with one-way learning, they as passive accept what is conveyed by the teacher. Because psychological conditions that feel comfortable and calm this becomes one of the factors that affect student learning results with expository strategies. In addition, the readiness of teachers in developing learning materials that will be presented to students in expository learning strategy must be complete and systematic, because the material conveyed by the teacher must be material that has been finished, and complete, without burdening the students to learn independently. this reinforces the results of our study, in students who have low self learning, expository strategies more appropriate than the PBL. However, the flipped classroom learning strategy is most effective for students with low self learning compared with both PBL and expository.

5. Conclusions

Learning strategy can influence learning result, it can be said that the learning strategy characteristics is specific, meaning that learning strategy will be effective if it suits the character of the subject, student character, and objectives to be achieved in the learning.

The learning strategy of flipped classroom is effectively applied to the thermochemistry and reaction rate learning material compared with problem based learning and expository strategies both for students who have high or low self learning.

The learning strategies of flipped classroom and problem based learning are equally effective in the learning of thermochemistry and reaction rate subject in students who have high self learning compared with expository strategies.

The expository learning strategy is more effective than the problem based learning strategy in student with low self learning, but no more effective than the flipped classroom strategy. An advice to teachers, to be able use the flipped classroom learning strategy in chemistry learning, especially on complex subjects, based algorithmic

calculations. The more quality the videos we prepare will motivate their spirit of the students in the process of self learning, and make more positive perception to the student in the learning process in the classroom, so that in the end will strengthen the student's knowledge and raise the learning results.

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