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Promoting Indonesian secondary school students' argumentation skills in the concept of chemistry reaction-rate: a comparative effect of three cooperative learning strategies

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Abstract. Argumentation skills have been minimally fostered in the worldwide science classrooms that brings students' low ability to make scientific arguments. This study had compared the effect of the strategies of jigsaw, two-stay-two-stray (TSTS), and discovery-learning (DL) in promoting Indonesian secondary school student's argumentation skills in the concept of chemistry reaction-rate. Data were collected using open-ended tests and video observations. The results of quantitative analysis show that jigsaw and TSTS were more effective than DL in enabling the students to produce high quality arguments. The results of observation data analysis show that distinctive learning experiences the students had in the form of chance to conduct diverse types of discussion under reasonable time allocation caused the differences of effect between the strategies. This finding suggests that implementing an argument-driven learning strategy that provides students with fruitful opportunities to perform intense debates is highly recommended to promote students' skills in scientific argumentation.

1. Introduction

Argumentation skills are notions that are supported by justifications [51]. These skills involve activities to make claims, finding evidence, give warrants, proposing backings and predicting qualifiers. Works of previous authors [51, 13] have given the details of these skills involving the way to use these skills in science classrooms.

Argumentation skills are similar to informal reasonings that people routinely use in daily life activities [54]. These skills are conveyed by the use of inductive thinking [25, 20, 41, 42] rather than the deductive one. When people encounter a problem, they normally try to find the reasons behind the problem. They try to look at the situations that stand behind the problem and make use of logical thinking to see connections between the situations and the problem. This way they are using argumentation skills. Thinking, thus, is the key component required in the process of making arguments particularly in the rhetoric of science.

Argumentation skills play central roles in developing students' understanding of science concepts [13, 54] including the chemistry's. These advocate students to criticize science



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concepts, allow them to scrutinize data and endorse them to make explanations that link the data to the concepts in the frame to approve or disapprove the concepts. Being engaged in such thinking phases, students may see the connections between the science concepts, the supporting data and the logical reasons. This process thus may help students understand the science concepts with ease. Therefore, learning achievements should be better cultivated from the process of thinking rather than memorizing and exercising/drilling.

Given the benefits of argumentation, teachers are expected to employ this activity in science classrooms. However, this practice is rarely implemented in many countries as schools exclude thinking and debate activities in science classrooms [25, 34, 38, 40, 52]. Science classrooms are mostly dominated by activities that provided little chances for students to perform inductive thinking in constructing arguments [38]. When teachers pose questions, sometimes they mostly pose questions that only need short and simple or repetitive answers [3, 23]. Consequently, students have low ability in making argumentations, for example in the subject of physics [52]. Thus, Kuhn [25] emphasizes the need for providing those students with opportunities to nurture their argumentation skills in science. This awareness increases along with the increasing awareness of the need for students to be able to use scientific thinking in regard to make claim, find data and pose explanations that relate data to scientific concepts [14, 15]. Matuk [33] reckoned that cooperative learning strategies are useful tools to achieve the goals. Using cooperative learning strategies, it is not only students' skills in making arguments that may improve but also do their science literacy and understandings of science [24].

Cooperative learning is designed and implemented by a science teacher to encourage students to learn inter-dependently and share responsibilities in a small heterogeneous group consisting 4-6 members [4, 30]. Students are encouraged to peer tutoring, to share ideas, and to manage data to complete the lesson [5, 18]. Teachers are recommended to be a facilitator who provides the necessary guidance [37] instead of being a content provider. Jigsaw, two-stay-two-stray (TSTS), and discovery learning (DL) are three strategies that belong to the cooperative learning strategies. The details of these strategies can be seen in the works of following authors [5, 18, 21, 22]. The use of cooperative learning strategies is effective in improving student learning success in science subjects [2], provides longer period for concepts to retain in students' minds [19, 45, 47] and is effective to increase students' activities in classrooms [6, 16, 26, 44, 46, 48]. Specifically, jigsaw strategy is successful to enhance students' learning outcomes [8, 43, 42, 28], participation and enthusiasm in learning science [35, 32] and activities, creative thinking ability, and confidence to learn science [28]. TSTS is also effective in enhancing the students' learning outcomes in mathematics [17], discussion skills [50] even motivation in social science [31]. Then, DL is also very good at improving students' achievements in chemistry concepts [39] and retentions of learning and perceived inquiry learning skills scores both on cognitive and affective levels in science concepts [7].

In addition, cooperative learning strategies are also effective in increasing students' argumentation skills. Inquiry learning has been effective in enhancing students' skills in making arguments in science subjects [52, 1, 12, 9] including in chemistry [36]. The use of scaffolding technics in a collaborative learning situations has also been effective in increasing students' problem-solving skills and argumentation skills in science [10]. These descriptions strengthen the premises about the ability of the cooperation-based learning strategies in helping students to gain their ability to make arguments.

Despite the fact of cooperative learning strategies' ability in increasing students' argumentation skills, however, little is known about the most effective cooperative learning strategy -amongst others- in promoting student's skills to make arguments. This includes knowledge about the characteristic of a cooperative learning strategy that is necessarily important to make it effective in promoting the skills. This knowledge is useful for a teacher when she/he is in a situation that requires her/him to make a decision of using a learning strategy with her/his students in an argumentation-driven classroom. A comparative study thus needs to be carried out on purpose to investigate different effects produced by

varies cooperative learning strategies on students' argumentation skills. The search also included characteristics of the strategies that may cause the differences.

This article, thus, reports on the results of a classroom-based study investigating the comparative effect of a jigsaw, two-stay-two-stray (TSTS), and discovery-learning (DL) strategies in promoting the argumentation skills of secondary school students in the concept of chemistry reaction-rate in Jambi Indonesia. Characteristics of the strategies that may cause the differences are also discussed. To guide the discussions, two questions have arisen as follow:

1. How effective are the jigsaw, TSTS, and DL in promoting the students' argumentation skills in the concept of chemistry reaction-rate in Jambi Indonesia?
2. What characteristics of the strategies do make the students' arguments different?

2. Methodology

This study was conducted in early 2018 (the second semester of schooling) in a school participant - the Jambi Secondary School (JSS)- which is involved in a project funded by the University of Jambi Indonesia. This project is on purpose to foster students' argumentation skills in diverse concepts of chemistry and to look at characteristics of implemented cooperative learning strategies that may produce different effects on the skills.

Since this study was not intended to make a generalization of the findings towards the larger population of secondary school students in Jambi city, thus, the participant students were only taken from the student population in the JSS using convenient sampling technic [11]. As a result, the researchers did not necessarily use pre-tests in the recruitment process. The utilization of pre-tests was unnecessary for this study as this study was designed to investigate the promoted argumentation skills in a cross-sectional fashion (between the jigsaw, TSTS, ad DL); thus, this study only needs the after-study argumentation tests. Meanwhile, the exclusion of pre-test was beneficial to eliminate the covariant effects of the pre-test on the results of the after-study argumentation test. Such covariant effects may occur from the contents of pre-tests which are normally sourced from the concepts that will be delivered in a study, in this case, is the concept of chemistry reaction-rate.

Using convenient sampling technic, the researchers could approach all the grade-eleven students of JSS to be the participants. These students were purposefully chosen to be the participants as they were having the concept of chemistry reaction-rate in the rolling curriculum when this study was conducted. As a result, 90 regular grade-eleven students showed their interests to be involved in this study. These students had similar marks of chemistry subject (between 70-80) in their first-semester achievement reports (between July to December as Indonesia applies July to June schooling schedule). They were male and female students aged between 15-16 years who had been taught chemistry using the same curriculum. A chemistry teacher of JSS had also been approached to be the teacher participant. She was informed to implement the three strategies with the 90 students in three consecutive meetings for 270 minutes (Table 1). The involvement of a single teacher was aimed at reducing the finding-bias that potentially emerged from the use of multi teachers. She holds a master degree in chemistry, aged above 50, has been certified as a professional teacher and had used the jigsaw, TSTS, and DL before.

Table 1. Descriptions of the lessons

Meetings/contents	Jigsaw (N=30)	TSTS (N=30)	DL (N=30)
Meeting 1/ Effect of temperatures and concentrations, 6 problems	5 home-groups (6 students each), 6 expert-groups (5 students each)	6 groups (5 students each)	6 groups (5 students each)
Meeting 2/ Effect of wide of surfaces and catalysts, 6 problems	5 home-groups (6 students each), 6 expert-groups (5 students each)	6 groups (5 students each)	6 groups (5 students each)
Meeting 3/ Determination of order of reactions, 6 problems	5 home-groups (6 students each), 6 expert-groups (5 students each)	6 groups (5 students each)	6 groups (5 students each)

The conduct of this study was started by assigning the student participants into three classes (jigsaw, TSTS, and DL). Students in each class implemented learning activities that follow the phases described in the result of the study and summarized in Table 5. They were involved in three consecutive meetings each for 90 minutes that engaged them to learn about the concept of the factors that affect chemistry reaction-rate (the temperatures, concentrations of chemical solution, width of particle surface, catalysts) and the concept of the order of reactions. The details of the lessons are presented in Table 1.

During the lessons, the teacher acted as a facilitator to guide the students to complete their tasks using argumentation skills that included only skills to make claim, find data, and propose reasons/explanations. The remaining two argumentation skills (pose backings and qualifiers) were excluded from this study as the researchers believed that these are too difficult for secondary school students in Jambi to perform. Meanwhile, some video observations were carried out to collect data about the implementation of the lessons. This includes data about the use of time allocation and the intensity of discussions wherein the students rehearse their argumentation skills.

At the end of the study, students were engaged in an open-ended after-study argumentation test. The test included ten items which covered the same topics discussed in the lessons. These items were constructed in accordance with the indicators of competency for the concept of chemistry reaction-rate advised in the Indonesia running curriculum. A rubric (Table 2) was also developed to cover the need of categorizing the students' answers into five levels of skills span from level 0 to level 4. The trustworthiness of the test and rubric was achieved by making an initial draft, followed by the conduct of member checking, revisions, and continues discussions process between the researchers. This content-validity process ended-up when the researchers came to an agreement about the fitness of the test and rubric with the research questions. Construct validity measurement which normally involves a pilot project was not applicable for this study as the after-study test embraced the high-stakes test in the form of an argumentation test which is unfamiliar for students in Jambi Indonesia. Therefore, this study only employed content-validity technic to guarantee the trustworthiness of the instruments.

Tabel 2. Rubric and scores for assessing the students' argumentation skills

Level	Score	Descriptions of argumentation skills
4	10	Claim is correct, data are relevant or correct, the reasons link the data to the claim
3	7.5	Claim is correct, data are relevant or correct, the reasons does not link the data to the claim
2	5	Claim is correct, data are irrelevant or incorrect, no reasons
1	2.5	Claim is incorrect, no data or incorrect data, no reasons
0	0	No or wrong answers at all

Finally, the collected data were analyzed using two fashions. The data tests were analyzed using a descriptive method by categorizing the students' answers into five level of skills (Table 2), followed by measuring the mean and standard deviation of the argument level. To check whether the three strategies produced different effects on the students' argumentation skills, SPSS-assisted one-way ANOVA was employed. Prior to the conduct of the test, however, the normality and homogeneity assumption of the data must be fulfilled. The result of the test show that each data was normal in which the p-value of each strategy > .05 (p-value of jigsaw = .18, p-value of TSTS = .096; and p-value of DL = .20) and the combined data were homogenous (p-value = .459 > .05), thus, the use of ANOVA was granted. Meanwhile, data from the video observations were analyzed by looking at the students' use of intense discussions and the time allocation the students spent for the conduct of the discussions in the frame of producing the arguments.

3. Results and Discussion

This study had involved 90 participant students in three parallel classes to learn the concept of chemistry reaction-rate using the jigsaw, the two-stay-two-stray (TSTS) and the discovery learning (DL) strategies for 270 minutes. This study had also encouraged them to make claim, evidence, and

reasons related to the concepts. The effect of the three strategies in promoting the students' argumentation skills and learning experiences that may have influenced the differences are discussed below.

3.1. Effectiveness of the jigsaw, TSTS, and DL in promoting the students' argumentation skills in the concept of chemistry reaction-rate in Jambi Indonesia

The first question discussed in this article is "How effective are the jigsaw, TSTS, and DL in promoting the students' argumentation skills in the concept of chemistry reaction-rate in Jambi Indonesia?". To answer this question, one-way ANOVA test had been employed. Based on the results of ANOVA test (Table 3), it is seen that the three strategies had produced significant different effects on the students' argumentation skills ($F=30.186$, $p\text{-value} < .05$) in the concept of chemistry reaction-rate. This finding was supported by other data showing that the jigsaw students had the highest argumentation skills represented by the mean scores of 85.5, followed by the TSTS students by the mean scores of 82.7 and the DL students by the mean scores of 72.6. This is parallel with other data describing the level of students' skills in making arguments. Data in Table 4 also reveal that the jigsaw students had the highest mean of skill (3.42), followed by the TSTS students (3.31) and the DL students (2.90). Moreover, this finding is also approved by the number of students in each class who could produce the level 4 argumentations. It is seen that the jigsaw class had the most number of students who could produce level 4 argumentations (47.7%), followed by the TSTS students (35.7%), and the DL students (6.7%). It can be said that the three strategies had different effectiveness in promoting the students' argumentation skills in the concept of chemistry rate of reaction.

Table 3. Results of students' argumentation skills test in the concept of chemistry reaction-rate

Learning strategies (n=30)	ANOVA	Mean Score	Standard Deviation	Mean of skill	Level of argumentation (%)			
					1	2	3	4
Jigsaw	$F=30.186$	85.5	6.07	3.42	-	5.7	46.7	47.7
TSTS	$\text{Sig} = .00$	82.7	7.16	3.31	-	5.0	59.3	35.7
Discovery Learning		72.6	7.02	2.90	-	16.3	77.0	6.7

However, to elaborate the evidence about the different effects produced by the three strategies, a post-hoc test was employed. The result of a Tukey HSD test (equal variances were assumed) show that there was insignificant difference between Jigsaw and TSTS ($p\text{-value} (.242) > .05$) but significant differences were existing between these two strategies and the DL ($p\text{-value} (.000) < .05$) in affecting the formation of the students' argumentation skills (Table 4). The mean differences between the strategies supported this finding in which jigsaw vs TSTS was small (2.8333) while jigsaw vs DL (12.9167*) and TSTS vs DL (10.0833*) were large. The lower and upper bound at 95% confidence interval between the strategies also supported this finding in which jigsaw vs TSTS was small (-1.3336 and 7.0002) while jigsaw vs DL (8.7498 and 17.0836) and TSTS vs DL (5.9164 and 14.2502) were large. This means that these three strategies helped the students improve their level of argumentation skills in different ways. The Jigsaw and TSTS strategies were more effective than DL in improving the students level of argumentations.

Table 4. The different effects of the three strategies on the students' argumentation skills

	Kat (I)	Kat (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Jigsaw	TSTS	2.8333	1.74751	.242	-1.3336	7.0002
		DL	12.9167*	1.74751	.000	8.7498	17.0836
	TSTS	DL	10.0833*	1.74751	.000	5.9164	14.2502

Interestingly, when the data were analyzed based on the quality of argumentation, similar evidence was obtained. Figure 1 shows that large number of jigsaw students (94.1%) were at the skill level 3 and 4 and this was very close to the number of TSTS students (95%) who were at the same level. Meanwhile, the number of DL students who were at the skill level 3 and 4 was smaller (83.7%).

Furthermore, Figure 1 also shows that as the prementioned that the jigsaw and the TSTS strategies enabled the students to mostly produce the level 3 and 4 arguments (94.1% and 95%) but the DL strategy enabled the students mostly to produce the level 2 and 3 arguments (93.3%). These findings affirm that jigsaw and TSTS were more effective in producing the high-quality arguments than the DL. The sample of the students' arguments in the level 2, 3, and 4 are presented in the Appendix.

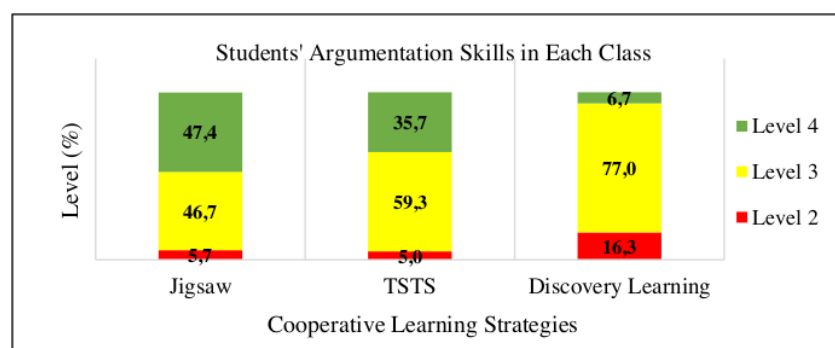


Figure 1. The level of students' argumentation skills

2. The characteristics of the strategies that make the students' arguments different

The second question discussed in this article is "What characteristics of the strategies do make the students' arguments different?". To answer this question, data had been taken from the video observations and used for the discussions. Therefore, the implementations of each strategy in each class are narrated below.

3.3. The implementation of the jigsaw strategy

At the start of the lessons, 30 students were assigned into five home-groups each consisting six students wherein a teacher introduced a brief explanation about the concept of chemistry reaction-rate and distributed six problems for the six students in each home-group. This means that the problem no 1 belonged to the student no 1 in each home-group, and so forth. The students spent 15 minutes (5 minutes for each meeting) to understand their individual task/problem and make their individual arguments. At the second step, the students formed six expert-groups each consisting five students who had the same problem. For example, all the students with problem no 1 from all the five home-groups gathered in the expert-group no 1, and so forth. The students spent 75 minutes (25 minutes for each meeting) to discuss the individual arguments in a comparative way and to formulate them into a single argument. At the third step, the students were instructed to get back into their home-groups. They spent 159 minutes (53 minutes for each meeting) to share and discuss the arguments they had formulated in the expert-groups in order to make a set of 6 "argument puzzles". At the final step, the students spent the remaining 21 minutes (7 minutes for each meeting) to be engaged in a classroom discussion to confirm all the accepted arguments.

3.3.1. The implementation of the TSTS strategy. At the start of the lessons, 30 students were assigned into six groups consisting five students in which a teacher introduced a brief explanation about the concept of chemistry reaction-rate and distributed one problem for each group. This means that the problem no 1 belonged to the group no 1, and so forth. Each group spent 60 minutes (20 minutes for each meeting) to understand their task/problem and make the relevant argument in the within-group discussions. At the second step, the students were instructed to do the 'two stay two stray' step, but as of each group consisted of five students thus this step was modified becoming 'three stay two stray'. This means that the three students stayed at their group to become the hosts and the other two students to become the visitors. The host students waited for the visiting students from other groups while the

wandered students visited the other groups. The students spent 120 minutes (40 minutes for each meeting) to share, discuss, and debate their arguments in between-group discussions. This step ended when all the visitors had met all the hosts of each group. At the third step, the visitor students went back to their own groups. They spent 60 minutes (20 minutes for each meeting) to conduct another within-group discussions in order to share, understand and discuss the arguments they had found from the other groups. They ended up with a set of 6 “argument puzzles”. At the final step, the students spent the remaining 30 minutes (10 minutes for each meeting) to conduct a classroom discussion to confirm all the accepted arguments.

3.3.2. The implementation of the DL strategy. At the start of the lessons, 30 students were exposed to a science phenomenon by having a lecturer-delivered material and reading text-book related to the concept of chemistry reaction-rate. The next step was assigning the students into six groups consisting five students in which the teacher distributed same six problems for each group. The teacher encouraged each student to make individual arguments related to the six problems and they spent 60 minutes (20 minutes for each meeting) to do this step. At the third step, the students compared the individual arguments to be a single approved argument covering the six problems. The students spent 150 minutes (50 minutes for each meeting) to do this step in the within-group discussions. Having had the final arguments, all the groups were invited to begin the final step in which they presented their results (the six arguments) in front of the class. They spent the remaining 60 minutes (20 minutes for each meeting) to compare all the arguments presented by all groups.

Based on the above descriptions, it is seen that the jigsaw and the TSTS students had more intense argumentative-discussions than those in the DL class. The jigsaw and TSTS students had two types of discussions which were the home and the expert group discussions, and the within-group and between-group discussions (the stay and stray discussions). This way, those students had a very big chance to share answers, scrutiny and discuss relevant data, and debate reasonable explanations with bigger numbers of the class member. In contrast, the DL students had only one type of discussion; a within group discussion that only provided them with a chance to discuss their works only with a small number of students, which was only with the students in each group.

Furthermore, data observation (Table 5) also revealed that the three strategies provided the students with different time allocation to conduct the argument-driven discussions. The jigsaw strategy - during the three meetings (270 minutes) - provided the rich opportunities for the students to conduct argumentative discussions both in the home and expert groups (249 minutes or 92.2%) and this was very close to the time spent by the TSTS students to do argumentative discussions both in the within and between-groups discussions (240 minutes or 88.9%). Meanwhile, the DL strategy only provided the students with 210 minutes (77.8%) to perform the argumentative discussions only in the within-group interactions.

Certainly, besides the group discussions, the students had the classroom communication sessions. However, the conduct of these activities was also seemingly different between the classes. The DL students had the classroom communication sessions for about 60 minutes (22.2%) in which they could refine and revise their arguments. Nevertheless, the classroom communication sessions looked ineffective in the DL class as there were so many arguments that need to be debated (as the arguments had not been debated in a kind of between-group discussion), but the time allocation were inadequate to facilitate all the debates (only 20 minutes available for each meeting). As a result, according to the observation, the teachers frequently took control of explaining the correct arguments due to the limited time without any information whether the students truly understand the arguments. The students were seemingly did ‘copy and paste’ work towards the teachers’ explanations. In contrast, even though the jigsaw students had only 21 minutes (7.8%) and the TSTS students had only 30 minutes (11.1%) for the classroom communication sessions but these activities looked more effective. This was because the students in these two classes had come up with similar arguments (attained during the between-group

discussions) prior to the classroom communication sessions. They only used these sessions to confirm their arguments rather than to debate as what the DL students did.

Table 5. Students' activities in the three consecutive argumentative lessons

Students' activities in argumentative phase	Jigsaw (270 minutes)	TSTS (270 minutes)	Discovery learning (270 minutes)
Engaging in contents and problems, and encouraging to make arguments	15 mins to understand 1 problem and make 1 individual argument in the home-group discussions	60 mins to understand 1 problem and make 1 argument in the within-group discussions	60 mins to understand 6 problems and try to make 6 individual arguments
- Searching and discussing claims	75 mins to compare the individual arguments and formulate them into 1 single argument in the expert-group discussions	120 mins to compare the arguments in the between-group discussions (stay and stray discussions)	150 mins to discuss and compare all the individual arguments with peers in the within-group discussions
- Searching and discussing relevant explanations			
Debating the results (claim, evidence, and warrant)	159 mins to match the "argument puzzles" into a set of 6 arguments in the home-group discussions	60 mins to match the "argument puzzles" into a set of 6 arguments in the within-group discussions	No activities in this step
Classroom communication	21 mins for classroom discussions	30 mins for classroom discussions	60 mins for classroom discussions

Based on the Table 5, therefore, it can be said that the rich opportunities - both in the form of diverse types of discussion and the time allocation- provided by the jigsaw and TSTS had been the key characteristics of the two strategies in helping the students generate high quality arguments. These students had been benefited by these two strategies with distinguishing learning experiences that enable them to obtain better understanding of the concept of chemistry reaction-rate and gained better skills in making scientific arguments (represented by the distinguishing scores and level of arguments). This inference is relevant with Zohar et al [54] who affirmed that engaging students with intense thinking activities will help the students with developed learning outcomes, that include skills in making arguments. Leonard [27] argues that the more involved are students in practical activities, that include activities to promote skills to make arguments, then the more learning outcomes that the students will achieve. Thus, these characteristics should be the central consideration of science teachers when choosing a particular learning strategy to be implemented with students in an argument-driven learning activity.

4. Conclusion

This study has been successful in helping 90 ten-grade students of the Jambi secondary school (JSS) in Jambi city Indonesia in promoting their skills in making arguments, particularly in the content of the chemistry rate of reaction. The strategies implemented were proven effective in doing so, yet with different effects. The jigsaw and TSTS strategies were evidenced more effective than the DL strategy in promoting the students' argumentation skills. The dissimilar type and intensity of discussions offered by the three strategies had appeared to be the key characteristics affecting the different magnitude of the promoted students' argumentation skills.

Despite that this study had been able to identify the comparative effects of those strategies including their affecting characteristics, some limitations were embedded in this study. The convenient sampling technic used in this study prevent the findings from being generalized to the larger part of the student population in Jambi city. Next study should cover this issue by utilizing the probability sampling technics. This also need to involve more schools and more subjects such as physics, biology and mathematics.

However, the findings of this study may be useful in enriching the reservoir of evidence about the benefit of cooperative learning strategies in increasing students' skills in making arguments in science. The characteristics identified in this study could be used as the guidance for any science teachers in choosing the most effective strategy fostering the students' argumentations skills in science classrooms.

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Appendix. A sample of a student's translated arguments categorized into level 2, 3, and 4.**Question 1. (Encouraging students to determine the effect of temperature)**

A reaction will occur as fast as twice if its temperature is raised by 10°C. At a temperature of 25°C, the reaction-rate of this reaction is 2a M/s. What do you think the rate of the reaction will be if the temperature at 75°C? Complete your claim with data and reasons!

Student's argument Level 4:

Claim : 64a

Evidence:
$$\begin{aligned} r_t &= A^{\Delta T/T} \times r_0 \\ &= 2^{75-25/10} \times 2a \text{ M/s} \\ &= 2^5 \times 2a \\ &= 32 \times 2a \\ &= 64a \end{aligned}$$

Reasons :

Temp (oC)	25	35	45	55	65	75
Reaction rate (M/s)	2a	4a	8a	16a	32a	64a

If the temperature is 75°C the rate of reaction will be 32 times higher than the initial rate (2a M/s). This follows the series of 2a, 4a, 8a, 16a, 32a, and 64a M/s.

Students' argument Level 3:

Claim : 64a

Evidence:
$$\begin{aligned} r_t &= A^{\Delta T/T} \times r_0 \\ &= 2^{75-25/10} \times 2a \text{ M/s} \\ &= 2^5 \times 2a \\ &= 32 \times 2a \\ &= 64a \end{aligned}$$

Reasons :

As counted the rate of reaction at 75° will be

Students' argument Level 2:

Claim : 64a

Evidence:
$$\begin{aligned} r_t &= (A)^{\frac{\Delta T}{T}} \times r_0 \\ &= 2^{\frac{75-25}{10}} \times 2a \\ &= 2 \times 5 \times 2a \\ &= 20a \end{aligned}$$

Reasons : No reasons

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