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The Role of Collaborative Learning Based STSE in Acid Base Chemistry: Effects on Students' Motivation

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ABSTRACT
Designing learning environment that leads on the improvement of students' motivation becomes crucial for chemistry teachers. The objective of this research was to investigate the effects of collaborative learning-based Science, Technology, Society, and Environment (STSE) towards students' motivation in acid base chemistry lesson. A pre-test post-test non-equivalent control group design was adopted in this quasi-experimental research. Two classes who enrolled in science programme from a public senior high school in Sleman Regency, Yogyakarta, Indonesia were used as the research sample of this study. Through cluster random sampling, one group was devoted as experimental class (N=30) receiving collaborative learning based STSE while the other one as control class (N=32) taught by traditional teaching. A Chemistry Motivation Scale (CMS) was administered as data collection tool of students' motivation before and after the teaching intervention. These data were analysed using descriptive statistics, Mann Whitney U, Kruskal Wallis, and Wilcoxon tests. The findings of this research revealed that there was significantly difference of students' motivation among experimental and control classes. This difference was occurred in favour of experimental class. Moreover, the data of students' motivation on experimental class signified a higher improvement than the control class. Thus, it can be highlighted that collaborative learning based STSE has an effect in improving students' motivation. The result of this study recommends to implement collaborative learning based STSE since it is promising in order to promote students' motivation in learning chemistry.

Keywords: *acid base, collaborative learning, STSE, motivation.*

1. INTRODUCTION

Making learning environment interesting for students become the challenge for teacher in all level of educational field. As all of the teacher, chemistry teacher had main role in conducting teaching learning instruction that brings on improvement of students' motivation in studying chemistry [1]. Since varied studies revealed that student had a lacked of students' interest, attitude, and motivation toward chemistry [2-3]; another study proven that it is because the meaningless of chemistry content [4-5]. Students considered chemistry as meaningless due to their inability in using chemistry content knowledge in overcoming real world problems. Further, they suggest that chemistry materials are not useable in their daily life [6-7]. Thus, the students pretend in studying chemistry including acid base chemistry. They found difficulties in making calculation of quantitative knowledge [8-9]; they regard acid base concepts are abstract [8, 10]; and the necessary of reasoning skill to understand the concept [9, 11]. Such the abstractness concept of acid base chemistry, students found difficulties in relating acid base chemistry knowledge and use it in everyday life. Thus, it implied on the decline of students' motivation and intention to learn acid base chemistry.

When the students had willingness in studying chemistry, they will gain what they deserved. This intention to learn chemistry that called as chemistry learning motivation. This motivation determines students' success and effectiveness in studying chemistry [12]. Motivation defined as someone strength that could arise individuals' intention in performing certain activity. If the source of intention comes from its individuals, it called intrinsic motivation. Whereas, if the source of intention comes from outside individuals, its known as extrinsic motivation. The higher students' motivation, the better students' attitude in the context of teaching learning instruction. As study performed by Suyanto, Wantini, Baidi and Amurdawati [13] recommends that students' motivation improves their desire to accomplish individual targets. This students' motivation influenced by their attention, relevance, and satisfaction [14]. Therefore, it is necessary to build students' motivation in order to attain a better students' learning outcomes [12, 15]. To deal with this issue, an appropriate learning strategy is required to promote students' motivation in learning acid base chemistry materials. The teacher needs to use their creativity to design chemistry learning environment that will attract students' interest and increase students' motivation. Thus, it will signify on the development of students' ability in relating chemistry concept with rapidly changing of societies.

Recent studies had been experienced various learning strategies in order to elicit students' motivation in learning chemistry. Augustinovič [16] suggest to implement interesting teaching methods using an embedded technology to construct students' engagement in teaching learning instruction. The role of technology had been implemented through the use of virtual laboratory [17]; flipped approach with peer-led team learning [15]; and computer-assisted instruction [18]. In addition, students' motivation had been developed through various pedagogies focused on student centred learning paradigm such as context-based learning [19-20]; socio-scientific issues from societal view [21]; guided inquiry learning with socio-scientific issues context [22]; 5E learning cycle [23]; case-based instruction [24-25] and inquiry-based teaching [26]. In another perspective, the interaction among students brings significant effects on students' motivation i.e., cooperative learning instruction for conceptual change [27] and cooperative integrated process inquiry [28]. As a conclusion the prominent opportunity to increase students' motivation is by providing students' engagement in learning activities through student centred learning [29]. Moreover, the increase of students' interaction in teaching learning instruction could become another alternative way to foster students' motivation. One of teaching pedagogy that facilitate students' engagement in active learning is through STSE approach. However, the use of STSE in chemistry learning still rarely performed [30-31].

The STSE approach present the linking of chemistry content knowledge with everyday life issues [31-32]. This STSE enables the students to make relationship among science, technology, society, and environment in authentic inquiry activities that necessary in solving daily life issues [33]. Since STSE integrates student centred learning paradigm, thus the students were actively participated in finding the new knowledge. The constructed knowledge they found could be extended in order to solve real world issues. Thus, the students are more aware with the problems close to their life. They understand the use of content knowledge in the everyday lives that could bring on their willingness in studying chemistry, hence it will boost students' motivation and interest in learning chemistry [34]. Moreover, the STSE makes students' engagement in teaching instruction enhanced, thus it allows the interaction among students in the class. This interaction could be facilitated using collaborative learning method that enables students to work in heterogeneous small group. The collaborative learning increases meaningful relationship among students in small groups in practicing and experiencing teaching learning [28]. The role of the teacher in this occasion act as facilitator [35]. This interaction improves students' motivation in facing real world problems.

As aforementioned discussion, this study offers on the implementation of collaborative learning based STSE. The collaborative learning based STSE integrates student centred learning theory. Thus, the STSE facilitating students in understanding acid base chemistry concepts that used in solving cases of everyday lives by their own. While in the collaborative learning, students perceived interaction among students, teaching materials, and the teacher. These kinds of interaction bring significant opportunity for students in finding acid base chemistry concept in meaningful way. Therefore, the combination of STSE with collaborative learning becomes interesting choice to increase students' motivation in learning acid base chemistry. The following research questions underlying the present study:

a. Is there any significant effect of the teaching intervention on students' motivation mean score between experimental and control class?
b. Is there any significant enhancement on students' motivation before and after the implementation of collaborative learning based STSE?

2. METHODS

The research methods conducted in this study explained in this section.

2.1. The Research Design

A pre-test post-test non-equivalent control group design was adopted in this quasi experimental research. Through this design, the study was investigated the effects of one or more experimental group which were given certain intervention with one comparison group that wasn't received treatment towards certain dependent variable [36]. Therefore, there were two different groups in this research, one group was devoted as experimental class receiving collaborative learning based STSE while the other one as control class taught by traditional teaching. The dependent variable measured in this research was students' motivation in studying acid base chemistry before and after the teaching intervention. The research design adopted in this research briefly presented in Table 1.

2.2 The Research Sample

As many as 62 eleventh grader who enrolled in science program from a public senior high school in Sleman Regency, Yogyakarta, Indonesia was used as the research sample of this study. These number of students were comprised from two classes; one group was devoted as experimental class and the other one as control class. A total of 30 students on experimental class (consisted of 14 boys and 16 girls) receiving collaborative learning based STSE and 32 students on control class (consisted of 16 boys and 16 girls) taught by traditional teaching.

The sample in this research came from similar economic background, have approximately aged 15-16 years old, no difference in term of students' prior knowledge in chemistry, and chosen by cluster random sampling since it assigned by selecting the groups rather than individuals [37]. The two classes in this research were followed all of research procedures, began by pre-test, teaching intervention, until the post-test.

2.3. The Research Procedure

This research was held in acid base chemistry lesson of eleventh senior high school grader of 2019/ 2020 academic year. The teaching learning instruction on acid base chemistry lesson was performed for 5 sessions on both classes. Further, the two classes were taught by the same chemistry teacher. The research procedures initiate by administered paper and pencil pre-test in the term of students' motivation, followed by giving teaching intervention, and closing by giving students' motivation post-test. The teaching intervention on both classes used student centred learning paradigm and they work in a collaborative group with each group consist of 3-4 students. Therefore, the students allow to construct their own knowledge through their selves and their peers in group discussion.

The experimental class taught by collaborative learning based STSE that have main characteristics learning phase of invitation, exploration, solution, application, and strengthen concept. The teaching learning activities in this group was initiating by presenting daily life phenomenon and the students need to correlate its relationship with the aspect of Science, Technology, Society, and Environment. Whereas on the control class was implemented scientific approach, a usual teaching learning instruction suggested by Indonesian curriculum. This scientific approach consists of observing, proposing question, collecting data, associating, and communicating activities. The brief different of teaching intervention on both classes shown in Table 2.

Table 1. A pre-test post-test non-equivalent control group design

Class	Pre-test	Experimental Treatment	Post-test
Experimental	CMS	Collaborative learning based STSE	CMS
Control	CMS	Traditional teaching	CMS
Description: CMS = Chemistry Motivation Scale			

Table 2. The instruction process on experimental and control class

Activity	Experimental	Control
Pre-test	Before the implementation of collaborative learning based STSE, the CMS was administered through paper and pencil test. The students accomplished the CMS for 30 minutes.	As the experimental group, students on control group dealing with CMS for 30 minutes before the acid base chemistry teaching.

Treatment	The phase of collaborative learning based STSE began by *invitation phase*. In this phase, the teacher gives daily life issue that developed in the society in order to attract students' interest with acid base chemistry teaching learning activities. After the students look into the issue, in the *exploration phase*, they need to discern the issues and discuss it with their peers in their group to construct their own knowledge. The students need to explore any references related the issue and try to make correlation with the aspect of science, technology, society, and environment. Next in the *solution phase*, the students require to discuss with their group regarding the strategy to solve the issue through the references they have had. In the *application phase*, the students given a chance to solve the problem using the content knowledge they have and the strategy they had been proposed. Thus, the students could overcome the daily life problem presented in the invitation phase. Finally, in the *strengthening concept phase*, the content knowledge that had been constructed by the students were emphasized by the teacher. Therefore, through collaborative learning based STSE makes the increase of students' ability in explaining science and development of technology that influence on society and environment.	The scientific approach initiates by *observing phase* that asking the students to observe certain teaching materials. Next, in the *proposing question phase*, the students need make several questions about the teaching material as much as possible. These questions would be managed by the teacher to guide the teaching learning instruction. After that, in the *collecting information phase*, the students explore any information from reliable resources to answer the questions they had been proposed. Further, in the *associating phase*, the students could solve any problems related the content knowledge they learned. They discuss the problems with their peers in their group. Finally, in the *communicating phase,* the students ask to present their ideas related the content knowledge they constructed. The teacher giving emphasize and add any additional information that may had not mention by the students.
Post-test	The CMS was reused to collect the data of students' motivation on experimental class after the collaborative learning based STSE had been finished to be implemented.	In order to collect the post-test data of students' motivation after the traditional teaching on acid base chemistry, the CMS was administered on the control class.

2.4. The Research Instrument

This research was collected the data of students' motivation in learning acid base chemistry before and after the experimental manipulation. To obtain these data, a Chemistry Motivation Scale (CMS) was administered as a data collection tool. The CMS is a questionnaire and belongs to non-test instrument which employs five points of Likert scale varied from strongly disagree until strongly agree. This CMS consisted of 40 items of statement that well distributed into positive and negative item. The scoring guide for positive item of CMS use following rule: the response for strongly agree signified 5 points; agree implied 4 points; doubt indicated 3 points; disagree signified 2 points; and strongly disagree implied 1 point. While, for the negative item using the contrast rule from the response for strongly agree signified 1 point until strongly disagree indicated 5 points. In addition, the CMS integrated several indicators of students' motivation with its distribution presented in Table 3.

The CMS use in this research was adapted from Vitrianingsih [38] with some necessary substantial changes. Thus, this CMS needs to be validated and it was performed through content and empirical validation. The CMS content validation began by asking the judgment from experts in chemistry education field. The experts checked the suitability of the indicators with each item, the correct Indonesian grammatical, and the motivation content knowledge.

The feedbacks from the experts were considered and important revision were made to improve the quality of CMS. After that, the revised version of CMS was administered towards a group of eleventh grader out of the sample of the research. The responses from the students were analysed in order to examine the empirical validity and reliability of the item. The result of the analysis presents that a total of 40 items were valid and found to be highly reliable since the Cronbach Alpha value signified 0.941 [39-40]. Thus, the CMS is a valid and reliable instrument to collect the data of students' motivation in this research.

Table 3. Indicators distribution on CMS

Sub Dimension	Indicators	Number of Item		Total items
		Positive	Negative	
Efficacy	Persevering in facing the acid base chemistry assignment	3	2	5
	Tenacious in facing acid base chemistry difficulties	3	2	5
Eagerness	Interested in studying acid base chemistry	3	2	5
	Having a high enthusiasm in solving acid base chemistry related daily life problems	4	1	5
Performance	Able to work independently or in a group	4	1	5
	Willingness in finishing regular task of acid base chemistry	3	2	5
Curiosity	Able to defend argument(s)	3	2	5
	Showing scepticism in arguing new knowledge(s)	3	2	5
	Total number of items	26	14	40

2.5. Data Analysis

The data of students' motivation before and after the teaching intervention in this research were analyzed using several procedures consisting descriptive statistics, Mann Whitney U, Kruskal Wallis, and Wilcoxon tests. The descriptive statistics was used to present the tendency central on students' motivation among experimental and control classes. In order to examine the significantly difference explaining the condition of students' motivation before and after the teaching intervention, Mann Whitney U test was employed in the analysis. Moreover, Kruskal Wallis test was utilized to determine the effects of teaching intervention on overall students' motivation with each dimension of motivation. The last, Wilcoxon test were performed to examine the improvement of students' motivation score before and after the collaborative learning based STSE had been implemented.

3. RESULTS AND DISCUSSION

The finding with its explanation and discussion concerning the result of this study presented in this section. The first is the result of descriptive statistics data on both, experimental and control classes covering the mean score, standard deviation, number of students, the highest, and the lowest score before and after the teaching intervention. The descriptive statistics on students' motivation among experimental and control classes present on Table 4. Examining the data on Table 4, it is implied that after the research treatment had been applied, students' motivation on experimental class signified a better score than the control class. Before the treatment, students on experimental class achieve pre-test score of 69.07. A slight difference on control class that achieve a higher pre-test score on students' motivation of 69.36. As a contrast, after the treatment, the experimental group had a higher mean score on students' motivation (M=71.25) than the control group (M=68.87). Thus, the students' motivation on control class were decline after the treatment. Further, the data of students' motivation before and after the teaching intervention were analyse using Mann Whitney U test. This analysis aims to check the mean score differences of pre-test and post-test on the two classes. The result of this analysis shown in Table 5.

Table 4. The descriptive statistics of the research on students' motivation

Parameter	Experimental		Control	
	Pre-test	Post-test	Pre-test	Post-test
Mean score	69.07	71.25	69.36	68.87
SD	4.10	4.81	5.24	5.91
Highest Score	77.50	80.00	79.00	88.00
Lowest Score	61.00	63.00	55.50	59.00
Ideal Score	100	100	100	100
Number of Students	30	30	32	32

Table 5 explains that before the teaching intervention, students' motivation among experimental and control classes shown no statistically significant difference. It means that before the treatment, students had similar motivation in learning acid base chemistry materials. Moreover, when the post-test data of students' motivation were examined, it found statistically significant difference among experimental and control groups in favour of experimental group. Thus, the intervention on experimental group that is collaborative learning based STSE contributes in improving students' motivation in learning acid base chemistry. Therefore, to examine the effects of this teaching intervention among experimental and control groups, Kruskal Wallis test was performed. See Table 6 to determine the effects of teaching intervention on students' motivation with each dimension of motivation

Based on the result of Kruskal Wallis test on Table 6, it is clearly depicted that collaborative learning based STSE had a significant effect on overall students' motivation, the dimension of students' motivation of efficacy, and eagerness. However, on the dimension of performance and curiosity of students' motivation signified no differences. Thus, collaborative learning based STSE had a significant influence on students' motivation especially on efficacy and eagerness dimensions. It explains that collaborative learning based STSE brings contribution a total of 16.9% in improving students' motivation with the dimension of efficacy signified 13.8% and eagerness of 9.1%.

The implementation of collaborative learning based STSE in this research boost students' motivation in learning acid base chemistry. The STSE allows the students to construct acid base chemistry content knowledge and linking it with daily life phenomena [31-32]. Realizing that acid base chemistry related with everyday problems, thus it attracts students' interest and intention in learning the materials. The STSE instruction provides an elaborated and deeper conceptual understanding. Therefore, it engages the role of students in learning activities that signified in affecting their motivation through the relevance of school chemistry to daily lives [23]. Given a related study arguing that higher students who are not motivated caused by the irrelevance of the course content [41], by implementing STSE in the acid base chemistry learning it provides the relevance of the content with students' life. Therefore, the research treatment on experimental class significantly influences students' motivation in studying acid base chemistry.

Phrased differently, in the chemistry learning, it is important to consider motivation because their success in chemistry is inherently tied to motivational and other affective processes [12].

Table 5. Mann Whitney U on pre-test and post-test mean score of experimental and control group

Test	Class	N	Mean Rank	Sum of Ranks	U	Sig	Conclusion*)
Pre-test	Experimental	30	30.02	900.50	435.500	0.530	No difference
	Control	32	32.89	1052.50			
Post-test	Experimental	30	36.55	1096.50	328.500	0.033	Significantly difference
	Control	32	26.77	856.50			

*) Confidence level of 95%

Table 6. Kruskal Wallis test on students' motivation among experimental and control class

Parameter	*Group*	*Mean Rank*	*df*	*Chi Square*	*P*	*Conclusion*)*	*Partial Eta Squared*
Overall Students' Motivation	Experimental	39.73	1	12.126	0.000	Significantly difference	0.169
	Control	23.78					
Efficacy	Experimental	38.90	1	9.842	0.002	Significantly difference	0.138
	Control	24.56					
Eagerness	Experimental	36.67	1	4.787	0.029	Significantly difference	0.091
	Control	26.66					
Performance	Experimental	35.30	1	2.600	0.107	No Difference	0.052
	Control	27.94					
Curiosity	Experimental	35.57	1	2.982	0.084	No Difference	0.051
	Control	27.69					

*) Confidence level of 95%

Table 7. Wilcoxon test results on experimental class

Parameter	N	Mean Rank	Sum of Ranks	Sig	Conclusion*)
Overall Students' Motivation					
Pre-test	30	11.17	33.50	0.000	Significantly difference
Post-test	30	13.80	317.50		
Efficacy					
Pre-test	30	11.00	33.00	0.000	Significantly difference
Post-test	30	13.27	292.00		
Eagerness					
Pre-test	30	13.75	55.00	0.003	Significantly difference
Post-test	30	12.86	270.00		
Performance					
Pre-test	30	13.21	92.50	0.097	No Difference
Post-test	30	12.21	207.50		
Curiosity					
Pre-test	30	8.78	79.00	0.200	No Difference
Post-test	30	12.67	152.00		

*) Confidence level of 95%

Facilitating direct interaction with peers, teaching materials, and the teacher were seen as key factors in improving students' pretention and motivation [29]. As the finding in this research, the interaction among the students on collaborative groups gives an influence on students' motivation. Using group collaboration, it brings students' willingness in performing all of teaching instruction. The collaborative learning increases meaningful relationship among students in small groups in practicing and experiencing teaching learning [28, 42]. Thus, the presence of well managed group discussion with their peers, boosts students' motivation in learning chemistry. Furthermore, to determine the improvement of overall students' motivation and each dimension of motivation before and after the students experienced collaborative learning based STSE, Wilcoxon test was executed (see Table 7).

Table 7 present the significant improvement of overall students' motivation with each dimension of motivation before and after collaborative learning based STSE had been treated. A statistically significant improvement found on the dimension of

eagerness and efficacy also overall students' motivation. The other two dimensions of motivation which were performance and curiosity signified no enhancement. The linking between chemistry concept with real world issues could develop students' efficacy. As an active learning, the constructed concept helps the students retain their knowledge in long term memory [43]. Thus, they tend to try their best in solving acid base chemistry cases using content knowledge that had been constructed by their own. Therefore, the increase of students' engagement in learning activities, improve students believe on their ability to solve the issues [44].

Through the presence of STSE learning, students discern the use of acid base chemistry knowledge in the everyday lives. It activates students' willingness in studying chemistry and boost students' motivation especially their eagerness in learning chemistry [34]. As an example, when the students learn about the reaction among acid and base solution, the students were given a case about heartburn phenomenon. Since the heartburn phenomenon caused by an excessive of acid, thus it should be cured by inhaling antacid. The students learn how the reaction of an acid in the human stomach with the antacid. This example of related phenomenon enhances students' eagerness in learning acid base chemistry. The result of this research confirmed by previous study that believe demonstrating teaching materials increase students' motivation in the instruction [45]. Accordingly, the implementation of collaborative learning based STSE in this research facilitating students to improve students' motivation in learning acid base chemistry concept.

4. CONCLUSION

Facilitating learning environment for students that could increase students' engagement and motivation in the chemistry lesson become major emphasis for all of chemistry teacher. The enhancement of students' motivation in studying chemistry become important since it is contributing in defining students' learning outcomes. In the light of the finding of this research, it is revealed that collaborative learning based STSE gives significant effects on students' motivation in studying chemistry. An improvement of students' motivation before and after the implementation of collaborative learning based STSE signified that linking the chemistry concept with everyday life issues attract students' efficacy and eagerness in studying chemistry. They are realizing the important of learning chemistry and the use of chemistry concept in the real-world life. Therefore, applying collaborative learning based STSE should be considered since it provides chemistry in meaningful way that contributes in dealing and pursuing future career for the students.

Seeing the result of this research, the collaborative learning based STSE could be performed with the distinction of chemistry subject areas and the grade level with the extent of research samples. For future studies, it is suggested to use blended learning mode in delivering chemistry content knowledge using STSE approach because the presence of online learning in this mode gives significant effects on students' self-efficacy as the part of motivation expectancy value [43, 46] and students' self-regulated learning [47]. Moreover, the addition of computer assisted instruction could be employ because it enables in improving students' performance and motivation in the certain subject [18] such as through flipped class room [48]. Thus, the effectiveness of collaborative learning based STSE in comprehensive result will be reveal.

AUTHORS' CONTRIBUTIONS

This study was a part of undergraduate thesis project by the fourth author. The research activities of the fourth author was under the supervision of the first three authors.

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