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Improving Student Discussion Activeness in Chemistry Education through Student Teams Achievement Division (STAD): A Classroom Action Research on Acid-Base Learning

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ABSTRACT

This classroom action research (CAR) investigated the use of the Student Teams Achievement Division (STAD) cooperative learning model to improve student activeness in group discussions during chemistry learning on acid-base material. The study was conducted with Grade 11 students and followed the CAR model through iterative stages of planning, action, observation, and reflection. Student activeness was evaluated through classroom observation, questionnaires, documentation, and field notes, with particular attention to questioning, expressing opinions, responding, and group cooperation. The implementation of STAD was associated with stronger participation in group discussions, supported individual responsibility, and encouraged students to contribute more actively to collaborative learning. STAD can provide an effective cooperative structure for improving student engagement in chemistry education, particularly in acid-base learning that requires discussion, conceptual reasoning, and active participation.

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1. INTRODUCTION

Chemistry education requires students to understand scientific concepts while actively participating in learning activities. Chemistry topics often involve abstract concepts, symbolic representations, observations, and reasoning processes that cannot be effectively developed through passive learning alone. Student participation is important because questioning, responding, expressing ideas, and engaging in learning activities are indicators of active learning [1, 2]. Acid-base chemistry requires students to understand interconnected concepts and apply them in problem-solving activities [3, 4]. Limited student participation can restrict opportunities for questioning, expressing opinions, and responding during classroom learning [1, 2]. Cooperative learning provides a potential solution because it structures interaction among students and distributes responsibility within small groups [5, 6]. Rather than positioning students only as recipients of information, cooperative learning encourages them to discuss, explain, respond, and contribute to achieving common learning objectives. Such interaction can support both academic learning and social participation.

Student Teams Achievement Division (STAD) is a cooperative learning model that can promote collaboration and student participation through structured group activities [5]. STAD organizes students into heterogeneous teams and combines classroom presentation, teamwork, individual responsibility, assessment, and group recognition. Through these components, students are encouraged to participate because individual learning contributes to group achievement. The structured cooperative activities in STAD can support student cooperation and participation during the learning process [5]. STAD is particularly relevant to chemistry education because collaborative discussion can provide students with opportunities to articulate chemical concepts and respond to different explanations. Students who initially hesitate to communicate in whole-class situations may participate more comfortably within smaller groups. At the same time, individual accountability is maintained because students remain responsible for their own understanding. Student activeness can be reflected through observable participation such as asking questions, responding, expressing ideas, and engaging in learning activities [1, 2]. In this study, these behaviors were operationalized as questioning, expressing opinions, responding, and group cooperation. These behaviors provide observable indicators of students' participation during chemistry discussion. Classroom Action Research (CAR) is appropriate for addressing this instructional problem because it enables classroom practices to be improved through iterative stages of planning, action, observation, and reflection. Problems identified during one cycle can be analyzed and used to improve subsequent learning activities. Thus, the approach emphasizes practical improvement within the actual classroom environment. Therefore, this study aimed to examine the implementation of STAD for improving student discussion activeness in Grade 11 chemistry learning on acid-base material. The study focuses specifically on changes in students' questioning, opinion expression, responding, and group cooperation during successive classroom action cycles. The study provides a classroom-based perspective on how structured cooperative learning can support active participation in chemistry education.

2. LITERATURE REVIEW

2.1. Student Activeness in Chemistry Education

Student activeness is an important component of meaningful learning. Active students do not merely receive information from teachers but participate through questioning, responding, discussing, explaining, and completing collaborative learning tasks. These activities provide opportunities for students to process information and communicate their understanding. In chemistry education, active participation is particularly relevant because conceptual understanding often requires students to connect observations with theoretical explanations and symbolic representations. Discussion can provide opportunities to compare interpretations, identify misunderstandings, and develop explanations collaboratively. Therefore, classroom interaction represents an important component of chemistry learning rather than an additional activity separated from conceptual learning. Student activeness can be observed through specific behaviors. In the present study, four indicators are emphasized: asking questions, expressing opinions, responding, and group cooperation. These indicators correspond directly to the observation instrument used during classroom implementation. Discussion-based participation also requires an environment in which students have opportunities and responsibilities to communicate. If discussion is dominated by a limited number of students, overall classroom activeness may remain low even when learning activities formally include group work. Therefore, an instructional model should provide both opportunities for collaboration and mechanisms encouraging individual participation.

2.2. Cooperative Learning

Cooperative learning organizes students into groups in which members work together toward shared academic objectives. The approach emphasizes interaction, responsibility, communication, and peer support. Students are expected to contribute to group learning while remaining individually responsible for understanding the material. Cooperative learning has been associated with increased interaction, cooperation, and student learning activity [5-7]. Students can exchange ideas, ask peers for clarification, respond to alternative explanations, and cooperate in completing tasks. These characteristics are relevant to science education, where discussion can help students construct and communicate conceptual understanding [5]. However, simply placing students into groups does not automatically produce meaningful cooperation. Group activities need an appropriate structure. Thus, participation is not concentrated among only a few students. Individual responsibility and shared group objectives are therefore important elements of cooperative learning. Within chemistry learning, cooperative activities can be particularly useful when students are required to discuss concepts and solve problems collectively. Acid-base learning provides such a context because students can exchange explanations, evaluate answers, and discuss relationships among chemical concepts.

2.3. Student Teams Achievement Division (STAD)

STAD is a cooperative learning model designed to combine group interaction with individual responsibility. Students are generally organized into heterogeneous groups, allowing members with different academic abilities to work together. The structure encourages students to assist one another because group achievement depends on the learning progress and participation of its members. The STAD process includes several interconnected components: presentation of learning material, organization of heterogeneous teams, collaborative learning activities, individual evaluation, and recognition of group achievement. These stages differentiate STAD from unstructured group discussion because students participate within a defined cooperative system [5]. The team-learning stage is particularly relevant to discussion activeness. During group activities, students can ask questions, express opinions, respond to other members, and cooperate in completing learning tasks. These behaviors correspond closely to the four indicators used to evaluate activeness in the present study. Previous educational studies have associated STAD with

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increased participation, motivation, cooperation, and learning outcomes [5]. These findings provide a theoretical basis for using STAD to address passive classroom discussion. Nevertheless, the effectiveness of the model depends on its classroom implementation, including group composition, learning tasks, teacher facilitation, and student responsibility. For acid-base chemistry, STAD provides a structured environment in which students can discuss conceptual questions and collectively evaluate their understanding. The model is therefore expected to support not only interaction among students but also greater involvement in chemistry learning activities.

2.4. Classroom Action Research (CAR) for Improving Discussion Activeness

CAR is an iterative approach directed toward improving actual teaching and learning practices. The process typically involves identifying a classroom problem, planning an intervention, implementing the action, observing its effects, and reflecting on the results before determining subsequent improvements. This iterative structure is relevant to student activeness because participation can change according to instructional conditions. Observation during each cycle allows the teacher and us to identify which aspects of classroom interaction require further improvement. In the present study, STAD was implemented through successive cycles of action and reflection. Student participation was evaluated using predefined indicators, while the findings from each cycle were used to assess whether the targeted level of classroom activeness had been achieved.

3. METHOD

The preliminary classroom observations reported in this study indicated limited student activeness during chemistry learning. Several students tended to remain passive during discussion, while classroom interaction was dominated by a smaller group of students. Preliminary classroom observations indicated that student participation in chemistry discussions remained limited, with several students tending to remain passive while classroom interaction was dominated by a smaller group of students. Here, the detailed information regarding our study is explained below.

3.1. Research Design and Participants

This study employed CAR. The research process consisted of iterative stages of planning, action, observation, and reflection. The approach was selected because the study focused on improving an identified classroom-learning problem through direct instructional intervention. The research was conducted at MAN 3 Sleman, Yogyakarta, Indonesia, with 32 students of Grade XI IPA 1 participating in the study. The intervention focused on chemistry learning on acid-base material. The research was conducted through successive classroom action cycles consisting of planning, action, observation, and reflection.

3.2. Classroom Action Procedure

The research procedure followed four stages in each cycle: planning, action, observation, and reflection.

(i) During the planning stage, we prepared the chemistry learning activities, STAD implementation procedures, discussion tasks, and observation instruments. Students were organized into heterogeneous groups to support interaction among learners with different characteristics and levels of achievement.
(ii) During the action stage, chemistry learning was implemented using STAD. The teacher introduced the learning material and organized students into teams. Students

subsequently worked collaboratively to discuss acid-base material and complete the assigned learning activities.

(iii) During the observation stage, student discussion activeness was monitored systematically. Observation focused on four indicators: asking questions, expressing opinions, responding, and group cooperation.

(iv) During the reflection stage, observations from the completed cycle were analyzed to identify strengths and remaining problems. The results were then used to determine improvements required in the subsequent cycle. This process continued until the predetermined success criterion for student activeness was achieved.

3.3. Data Collection

Data were collected using observation, questionnaires, documentation, and field notes. Observation was the primary method for recording students' discussion activeness during STAD implementation. Questionnaires were used to complement observational information, while documentation and field notes provided additional records of classroom activities. The observation instrument evaluated four indicators of discussion activeness, as summarized in **Table 1**. The instrument focuses on observable forms of participation rather than general impressions of classroom activity. These indicators were used consistently to evaluate student discussion activeness during the action cycles.

Table 1. Indicators of student discussion activeness.

NO.	INDICATOR	OBSERVED BEHAVIOR
1	Asking questions	Students actively ask questions related to the learning material or group discussion.
2	Expressing opinions	Students communicate ideas, explanations, or viewpoints during discussion.
3	Responding	Students respond to questions, statements, or ideas presented during learning.
4	Group cooperation	Students participate and cooperate with other members in completing group activities.

3.4. Data Analysis

Student discussion activeness was analyzed descriptively using the observation results. The percentage of individual student activeness was calculated using $P_i = \frac{S_i}{S_{\max}} \times 100$, where *Pi* represents the percentage of individual activeness, *Si* is the score obtained by an individual student, and *Smax* is the maximum possible score. The calculated percentage was interpreted according to the individual student activeness criteria presented in **Table 2**. Higher percentages indicate stronger participation in classroom discussion. Individual activeness was classified into four categories: Very Active, Active, Moderately Active, and Less Active. These categories were used to classify individual activeness based on the observation scores. In addition to individual activeness, classical completeness was calculated to determine the proportion of students who achieved the expected activeness criterion. Classical completeness was calculated using $P_c = \frac{N_a}{N} \times 100$, where *Pc* represents classical completeness, *Na* is the number of students achieving the specified activeness criterion, and *N* is the total number of students. The criterion for classical completeness is presented in **Table 3**. The classroom action was considered successful when at least 80% of students achieved the minimum “Active” category. The intervention was considered successful when classical completeness reached at least 80%. This criterion provided the basis for determining whether STAD implementation had achieved the intended improvement in student discussion activeness.

Table 2. Criteria for individual student activeness.

PERCENTAGE	CATEGORY
86-100%	Very active
71-85%	Active
56-70%	Moderately active
0-55%	Less active

Table 3. Criteria for classical completeness of student activeness.

PERCENTAGE	INTERPRETATION
81-100%	Successful
0-80%	Not yet successful

4. RESULTS AND DISCUSSION

4.1. Implementation of STAD in Acid-Base Chemistry Learning

The implementation of STAD was conducted as a classroom intervention to increase student participation during discussions of acid-base chemistry. The learning process emphasized heterogeneous teamwork, individual participation, discussion, and shared responsibility. These components were selected to address the initial classroom problem in which participation was concentrated among a limited number of students, while other students tended to remain passive during discussion. During the implementation, students were organized into heterogeneous groups and encouraged to participate actively in completing the assigned chemistry learning activities. The STAD structure provided opportunities for students to communicate within smaller groups rather than depending entirely on teacher-centered interaction. This arrangement was particularly relevant to the four indicators evaluated in this study: asking questions, expressing opinions, responding, and group cooperation. The implementation of STAD was conducted through successive classroom action cycles. Observation and reflection were used to identify limitations in one cycle and determine improvements for the subsequent cycle. This iterative process is important because student activeness is not determined solely by the learning model but also by classroom organization, teacher facilitation, group interaction, and students' willingness to participate. The use of cooperative learning for improving classroom interaction is consistent with previous studies reporting positive effects of structured group learning on student participation and learning outcomes [5]. STAD differs from ordinary group discussion because students are expected to contribute both individually and collectively. This structure can reduce the possibility that group activities are dominated by only one or two students. In acid-base chemistry, such interaction is useful because students need opportunities to communicate their understanding, evaluate different explanations, and respond to questions. Therefore, the STAD implementation was not intended merely to increase the frequency of student communication but to provide a structured environment for meaningful participation in chemistry learning.

4.2. Development of Student Discussion Activeness

The classroom observations showed changes in students' discussion participation following the implementation of STAD. The evaluation focused on the four indicators previously presented in **Table 1**: asking questions, expressing opinions, responding, and group cooperation. These indicators allowed classroom activeness to be evaluated through observable student behaviors rather than through general impressions of participation. The distribution of student activeness during the classroom action process showed that 13 indicators (54%) were classified as active, 2 indicators (8%) as moderately active, and 9 indicators (38%) as less active, while no indicators were categorized as very active. The majority of the observed activeness indicators had reached the active category, although several aspects of student participation still required improvement. The distribution complements the individual and classical activeness and provides a more detailed picture of student participation during STAD implementation. The observed development of participation is consistent with cooperative-learning research showing that structured group activities can increase student interaction and engagement [5, 6]. Students who may be reluctant to speak in front of the entire class can first communicate within their teams. In addition, group responsibility encourages members to participate because completion of the learning activity depends on interaction among team members. STAD can support student cooperation and participation in group learning [5]. The findings of the present CAR are consistent with this direction because the implementation was accompanied by greater participation during the discussion activities. However, student activeness should not be interpreted simply as the number of students who speak during class. The quality and purpose of participation are also important. For this reason, the observation instrument distinguished questioning, expressing opinions, responding, and cooperation. A student who actively responds to a peer or contributes to completing a group task demonstrates a different form of participation from a student who asks questions, but both behaviors contribute to collaborative learning.

4.3. Asking Questions and Expressing Opinions

Asking questions represents an important form of participation because students are engaging with the learning material and identifying aspects that require clarification. In chemistry learning, questions can also reveal difficulties in understanding terminology, conceptual relationships, or the application of chemical principles. The STAD learning environment provided opportunities for students to ask questions within their groups before or during wider classroom discussion. This smaller-group setting can reduce barriers to participation because students interact directly with peers who are working on the same task. Expressing opinions was another indicator evaluated in this study. Students were encouraged to communicate their ideas during group discussion rather than waiting for the teacher to provide all explanations. This process is particularly relevant in acid-base learning because students need to articulate relationships among concepts and evaluate alternative explanations. The development of questioning and opinion expression is consistent with the basic purpose of cooperative learning. Students are not expected to receive information passively; instead, they participate in constructing and communicating understanding. Structured cooperative approaches such as STAD can facilitate this interaction by giving students defined opportunities to contribute to group activities [5]. Nevertheless, increased communication should not automatically be equated with improved conceptual understanding. The present study primarily evaluated discussion activeness, not detailed conceptual change. Therefore, the findings support the effectiveness of STAD for increasing observable classroom participation but should not be extended beyond the variables actually measured.

4.4. Responding and Group Cooperation

Responding to questions and statements represents another important aspect of active discussion. A classroom discussion requires interaction among participants rather than isolated individual contributions. When students respond to peers, they are required to pay attention to the discussion and formulate an appropriate reaction. The STAD structure supported this process by placing students in teams with shared learning responsibilities. Students could respond to questions, compare ideas, and assist other group members during chemistry learning activities. Such interaction can create a more participatory learning environment than instruction dominated by one-way communication from teacher to students. Group cooperation was also evaluated as a separate indicator because participation in STAD depends on interaction among team members. Cooperation includes involvement in completing group tasks and contributing to the learning activities of the team. This indicator is particularly important because the presence of groups does not necessarily guarantee cooperative learning. A group may formally complete an assignment while only a few members perform most of the work. The use of heterogeneous groups in STAD was intended to reduce this problem by encouraging students with different characteristics and achievement levels to work together. Individual responsibility remained important because the contribution of each student was connected with the functioning of the team. These characteristics support the use of STAD as a cooperative strategy for strengthening group cooperation and student participation [5]. In the present chemistry classroom, the combination of teamwork and individual participation provided a practical structure for addressing passive discussion behavior.

4.5. Development across the Classroom Action Cycles

The iterative nature of CAR was central to the interpretation of the findings. The purpose of the cycles was not merely to repeat the same instructional activity but to use observation and reflection to improve subsequent implementation. Student discussion activeness showed positive development during the implementation of STAD across the classroom action cycles. Student discussion activeness increased during the STAD implementation. Therefore, the defensible interpretation is that participation developed positively across the classroom action process without assigning an unsupported baseline value. The success criteria presented previously in **Tables 2 and 3** provide the framework for interpreting this development. **Table 2** classifies individual students according to their percentage of observed activeness, whereas **Table 3** evaluates classical completeness at the classroom level. Thus, the two tables represent complementary forms of evaluation: one focuses on individual participation and the other on overall classroom achievement.

4.6. Implications for Chemistry Education

The findings have practical implications for chemistry teaching.

(i) Structured cooperative learning can be useful when the instructional problem involves limited classroom participation. STAD provides clear roles for teamwork and individual contribution, allowing teachers to organize discussion more systematically than through unstructured group activities. Recent chemistry-education studies have highlighted the role of technology-supported learning [8, 9] and instructional strategies for improving acid-base performance and chemistry learning motivation [10, 11].

(ii) Discussion activeness should be evaluated using multiple observable behaviors. Asking questions alone does not represent the entire concept of participation. Students may contribute through expressing opinions, responding to peers, or cooperating in group tasks. The four indicators used in **Table 1** therefore provide a broader representation of classroom engagement.

(iii) The context of chemistry education is important. Acid-base learning involves concepts that can benefit from explanation and discussion among students. Cooperative interaction gives learners opportunities to verbalize their understanding and respond to alternative ideas. Therefore, STAD can function not only as a classroom-management strategy but also as a structure for supporting communication around chemistry concepts.

The findings are consistent with previous evidence showing that STAD can strengthen student cooperation and participation during group learning [5]. However, the present study specifically contributes a classroom-based application to discussion activeness in acid-base chemistry rather than establishing the universal effectiveness of STAD.

4.7. Limitations and Interpretation of the Findings

Several limitations should be considered.

(i) This study was conducted within a single classroom involving 32 students. Its primary purpose was to improve classroom practice rather than establish broad causal generalizations.

(ii) The study evaluated observable discussion activeness. Although active discussion may support learning, the present data do not independently establish that increased activeness caused improvement in chemistry conceptual understanding or academic achievement. Such conclusions would require additional learning-outcome measurements.

(iii) The interpretation of changes in student activeness is limited by incomplete consistency in the reporting of the initial activeness level and the number of classroom meetings conducted within each cycle. Therefore, the findings should be interpreted primarily from the verified classroom observations and final activeness outcomes reported in this study. More consistent documentation of baseline conditions and intervention procedures is recommended in future CAR.

Despite these limitations, the classroom observations consistently indicate that STAD provided a more participatory structure for chemistry discussion. The individual and classical evaluation procedures, together with the criteria in **Tables 1-3**, provide the basis for interpreting student activeness. The findings support STAD as a practical cooperative-learning approach for increasing observable participation in acid-base chemistry discussions while emphasizing the need for accurate and consistent classroom documentation.

5. CONCLUSION

The implementation of STAD provided a structured cooperative environment for improving student discussion activeness in acid-base chemistry learning. Students participated through asking questions, expressing opinions, responding to peers, and cooperating within heterogeneous groups. The CAR process indicated positive development in participation across the implemented cycles. STAD can support active chemistry learning by combining individual responsibility with collaborative interaction. The findings should be interpreted within the classroom context because the study focused on observable discussion activeness in a single class. Accurate reporting of baseline observations and classroom procedures remains essential for strengthening the reliability of the study's conclusions.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper is free from plagiarism.

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