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Effectiveness of Toulmin's Argumentation Pattern (TAP) with Snowball Media on Student Learning Outcomes in Acid-Base

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Abstract
The enhancement of classroom learning achievements can be attained through the implementation of instructional approaches that are both efficient and aligned with students specific requirements. This study focuses to evaluate how effectively the integration of the Toulmin's Argumentation Pattern (TAP) framework with snowball-based media on students achievement in acid-base material. The novelty of this study lies in the direct integration of snowball media within the TAP argumentative framework. Previous research has applied TAP or snowball separately, but no studies have combined both approaches into a single structured model, particularly for acid-base material. This integration introduces a new instructional innovation that merges systematic reasoning with interactive peer engagement. The TAP learning model will encourage students to develop structured reasoning and critical thinking, while snowball media is used to increase interaction between students through fun and collaborative question and answer activities. Pre-experimental research used a one group pretest-posttest design involving 36 students of class XI-D SMAN 7 Samarinda selected through purposive sampling based on class activity and schedule suitability. Data analysis included normality test, N-Gain, and effect size calculation. The average learning outcomes increased from 7.22 in the pretest to 69.16 in the posttest. The average N-Gain value is 0.67 indicate moderate improvement, while the Effect Size value is 4.91 showed a very high impact. These results confirm that TAP learning design combined with snowball media is highly effective in improving student learning outcomes on acid-base materials.

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INTRODUCTION

Education represents a deliberate and systematically designed process to able build a learning environments to actively explore and enhance student abilities and potential. This can be achieved through the selection of appropriate materials, activity strategies, and assessment techniques (Hasan et al., 2021; Triwiyanto, 2021). In the field of chemistry, lessons are often considered difficult by students because the materials are abstract and complex. One topic often challenging is acid and base, which include concepts such as ionization, pH, and interactions between acid and base. Students often struggle to relate these concepts to real life phenomena (Akbar dan Djakariah, 2024). These challenges emphasize the need for instructional innovations that can support both conceptual understanding and active engagement, especially on topics that require logical reasoning such as acid–base chemistry (Susanti et al., 2021)

The Toulmin's Argumentation Pattern (TAP) is widely used to analyze and improve argumentation in science education. This model helps improve students' understanding by developing students' ability to think systematically and make structured arguments. In this model, there are six key elements that are the basis of claim, data, warrant, backing, rebuttal, and qualifier in the thinking process, thereby encouraging students to think critically (Erduran, 2019; Haryani et al., 2021; Sudarini et al., 2022; Toulmin, 2003). The structured approach helps students to evaluate and form their own arguments by identifying them first (Al Fraidan, 2025; Lin & Jiao, 2026; Su et al., 2021; Yang, 2022). Although in its concept TAP has a good structured method, this model also has limitations where students often have difficulties in compiling complete arguments, especially to refute and counter-argument (Mirzababaei & Pammer-Schindler, 2021). The TAP method tends to focus too much on developing critical and analytical thinking skills but leaves out collaborative aspects and social interaction (Marsi et al., 2024). This limitation creates an opportunity for integrating strategies that promote interaction and peer negotiation, making TAP more balanced between cognitive reasoning and collaborative engagement.

This is a learning media that stimulates students to take part in activities in a fun manner. This learning method allows students to have an opportunity to jot down their ideas in a paper that is designed in a ball form, which they toss to one another. In this activity, students replied to a question based on a ball that was caught (Manalu et al., 2022; Saputeri & Annisa, 2024; Siahaan et al., 2021). That way, there is interaction between students, making the classroom atmosphere livelier and more interactive (Arends & Kilcher, 2010; Mariam et al., 2024; Sefira et al., 2024). The snowball technique strengthens social interaction and encourages immediate peer feedback, making it a potential complement to argumentation-based learning models.

The integration of the TAP method and Snowball will help in developing two important aspects of learning; whereas TAP focuses on critical thinking skills, it is supported by snowball in terms of social interaction (Hähkiöniemi et al., 2022; Ma et al., 2025). So in this study, an assessment was conducted during this research regarding the effectiveness of learning through Toulmin's Argumentation Pattern combining snowball as media for improving students' outcomes in learning about acid-base topics. This combination has not been specifically applied to acid base concepts, so this study fills a research gap by testing a structured argumentation model together with an interactive collaborative activity. The study aims to provide a new alternative learning that helps students think critically while staying active in discussion.

METHOD

This study employed a pre-experimental approach, with a one-group pre-post test design. The population in this study involves grade XI students at SMAN 7 Samarinda in the 2024/2025 academic year, consisting of six classes of grade XI students at the school. Sample selection used a purposive sampling technique. With this approach, the researcher selected participants based on specific criteria (Suartha et al., 2020). Class XI-D was selected since its schedule aligned with the implementation period and the class showed consistent activeness in chemistry lessons. These criteria ensured that the TAP and snowball media learning stages could run without reducing teaching time or disrupting school routines. Researchers also considered classroom characteristics, including student readiness, interaction patterns, and teacher input on class dynamics. Environmental factors such as classroom atmosphere, peer interaction, and teacher facilitation were considered because they influence the effectiveness of collaborative and argumentation-based learning models. Test and non-test type of instrument was used in this study. The instruments consisted of a pretest and a posttest used to assess student learning outcomes. Meanwhile, the non-test instrument included observation sheets of teacher and student in school activities, and student response questionnaires (Wang & Hu, 2025).

This study used two methods in processing data, namely descriptive approach and advanced statistical approach. The advanced statistical aproach begins by testing whether the data have a normal distribution (Pasaribu et al., 2024). The test results indicate that the data were not normal distribution, so a non-parametric statistical method was chosen, namely the wilcoxon signed-rank test. This method was chosen because it is suitable for analyzing paired data from the same participants and does not require normal distribution assumptions. This test helped assess whether the TAP–Snowball intervention produced a statistically meaningful change in student performance and was appropriate considering the varying characteristics of student learning data (Samini et al., 2025).

Student learning success was assessed using written test, with scoring determined by the percentage of the maximum score obtained. The scores obtained were then grouped into specific categories to facilitate the interpretation of student competency achievement levels (Alfath & Raharjo, 2019). The grade criteria categories shown in Table 1.

Table 1. Student grade criteria categories

Score	**Categories**
$80 < x \leq 100$	Very High
$70 < x \leq 80$	High
$55 < x \leq 70$	Moderate
$40 < x \leq 55$	Low
$0 < x \leq 40$	Very Low

In order to understand to what extent a combination of Toulmin's Argumentation Pattern (TAP) and snowball media was effective in enhancing learning achievements in acid-base topics, a pretest and posttest score analysis was carried out employing a formula of normalized gains. Before the analysis was performed, that data was first tested to meet the statistical requirements through normality and homogeneity tests, then the N-Gain calculation was performed according to the formula presented by Indra & Cahyaningrum (2019).

$$Normalized\ Gain\ (g) = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score}$$

The calculation results were then adjusted as below.

Table 2. Gain score index criteria

Index *Gain*	**Category**
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Moderate
$g < 0.3$	Low

N-Gain analysis aside, the efficacy of learning is also supported by measuring effect size through cohen's formula (Widyastuti dan Airlanda, 2021). In measuring learning efficacy through effect size, it is aimed to analyze the gravity of influence created by employing TAP model and snowball media in taking part in students' learning achievements. The formula of calculating effect size as follows:

$$d = \frac{(M_2 - M_1)}{\sqrt{\frac{SD\ 1^2 + SD\ 2^2}{2}}}$$

Explanation:
d = effect size
M1 = mean pretest score
M2 = mean posttest score
SD1 = pretest standard deviation
SD2 = posttest standard deviation

The calculation results are then adjusted based on the interpretation of size impact in the table below (Widyastuti et al., 2021).

Table 3. Effect size interpretation

Effect Size	**Interpretation**
0 < d < 0,2	Small
0,2 < d ≤ 0,5	Moderate
0,5 < d ≤ 0,8	Large
d > 0,8	Very Large

Using both analyses (N-Gain and Effect Size), the effectiveness of the TAP model assisted by snowball media is not only seen from the increase in learning outcomes, but also from the strength of the treatment's influence on these changes statistically and practically.

RESULTS AND DISCUSSION

Data on the improvement in learning outcomes of students in class XI-D at SMAN 7 Samarinda was obtained from the results of the pretest and posttest.

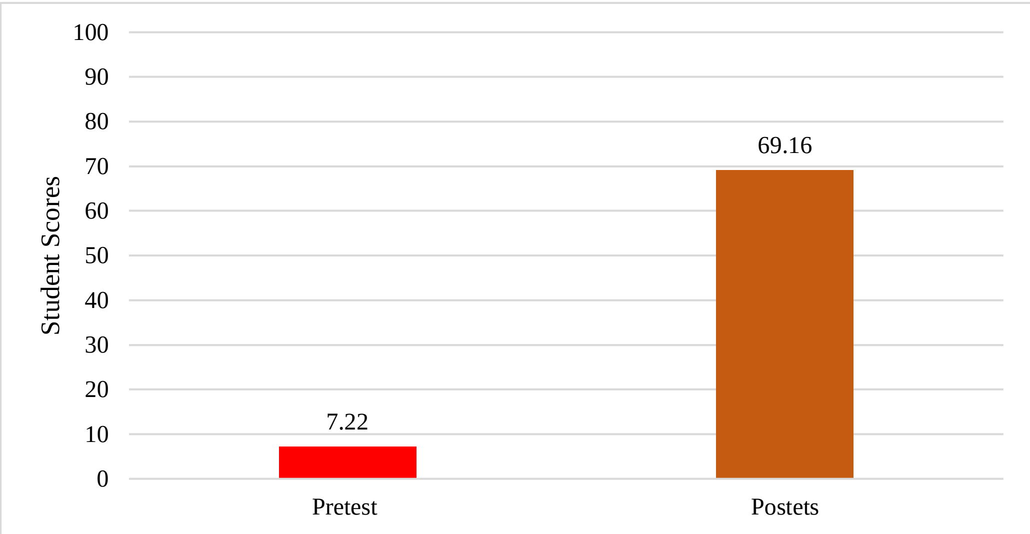

Figure 1. Average results of pretest and posttest scores

Figure 1 illustrates a noticeable improvement in students' learning performance after the aplication from the Toulmin's Argumentation Pattern (TAP) learning model combined with snowball media. To measure the effectiveness of this model, N-Gain and Effect Size test were conducted. Before that, normality tests were performed using the Shapiro-Wilk method through the SPSS software to evaluate both pre and post test score were normal distribution, as show in Table 4.

Table 4. Normality Test Results

Class	**Data**	***Sig.***	**Description**
XI-D	*Pretest*	0.000	Not normally distributed
	Posttest	0.012	Not normally distributed

Analytic result from pre and post test are not normally distribute (sig.< 0.05), as shown in Table 4, with significance values of 0.000 and 0.012, indicating that teh assumption of normality was not achived. Therefore, the analysis was continued using the Wilcoxon non-parametric test, whic was considered relevant for analyzing non-normally distributed data, and was applied to determining the improvement in learning outcomes resulted after implementating the TAP model with snowball media (Zhang, 2025).

Table 5. Non Parametric Test Result

Wilcoxon W	630.00
Z	-5.164
Asymp. Sig. (2-tailed)	0.000

Table 5 presents an Asymp. Sig. (2-tailed) value of 0.000, signifying a statistically clear significant difference In both pre and posttest scores. This results indicate that TAP implementation model combined with snowball media produced a clear significant impact on student learning outcomes. Consequently, the analysis proceeded with the N-Gain test, which was utilized to examine the magnitude of increasing students' learning achievement following the implementation of the TAP model integrated with snowball media.

Table 6. N-Gain Test Results

Class	**Average *Pretest***	**Average *Posttest***	***N-Gain***	**Category**
XI-D	7.22	69.16	0.67	Moderate

Table 6 shows N-Gain value of 0.67 in the moderate category suggests a practical improvement in conceptual understanding. Students did not only recalling acid-base definitions but were able to connect concepts such as pH, ionization, and acid strength more coherently through structured argumentation supported by interactive snowball questioning. To further measure the strength of the intervention effect, an effect size calculation was added.

Table 7. Effect Size Test Results

∑ *Pretets*	**∑ *Posttest***	***Std*.Deviation *Pretest***	***Std*.Deviation *Posttest***	***Effect Size***	**Category**
7.22	69.16	9.8789	23.2224	4.91	Very High

Table 7 shows the results of the Effect Size analysis of 4.91, which is classified as very high. This very high value indicates a strong practical influence of the TAP-Snowball model. Students showed substantial progress in organizing scientific reasoning, defending claims, and explaining chemical phenomena compared to conventional learning methods. The combination of TAP's structured reasoning and Snowball's interactive questioning provided students with both cognitive and social support to process acid-base concepts more effectively.

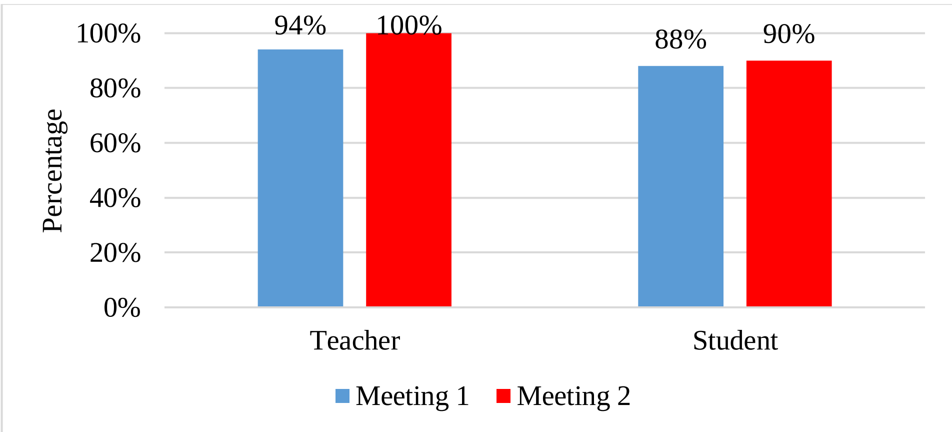

Figure 2. Teacher and Student Activities

During the learning process, supporting data was also obtained from observations of classroom activities and student responses through questionnaires, which reflected positive responses to the use of the TAP model with snowball media.

Observation in Figure 2 show that student activity increased from 88% to 90%, with 89% of it was in good category as an average position. Teacher activity also increased from 94% to 100%, and 97% of it was in very good category as an average. The increase in activity reflects that the model encouraged students to participate more actively. TAP required them to formulate claims and warrants, while snowball media required immediate peer interaction. These two processes increased students' engagement and sustained their attention throughout the lesson.

As supporting data, an effectiveness students questionnaire was given at the end of the lessons to evaluate their response to the application of the TAP model with snowball media on acid-base material. The questionnaire covered five aspect, student engagement in learning, conceptual understanding, thinking skills, learning atmosphere, and effectiveness of material delivery. The data collected provided information used to evaluate the effectiveness of the teaching approach in active participation and improving learning outcomes.

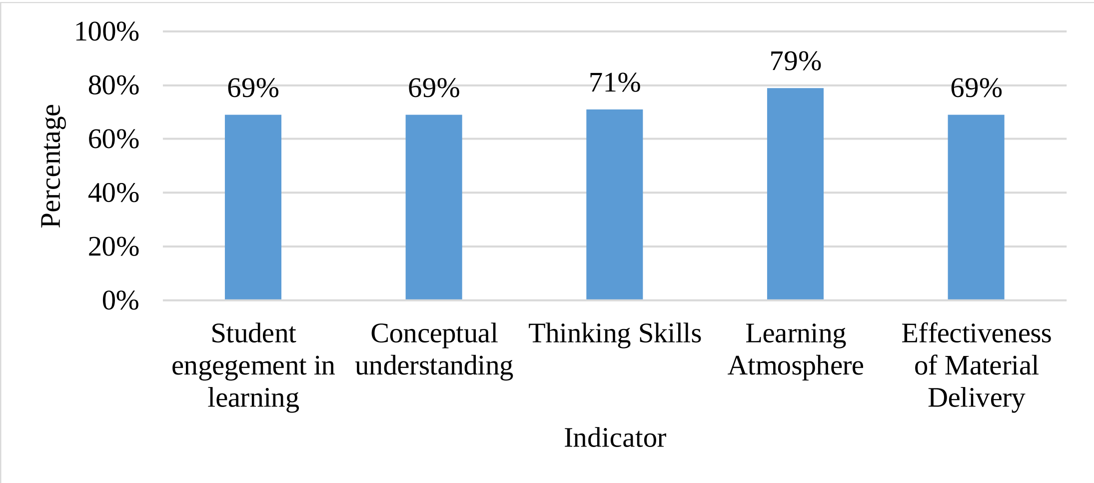

Figure 3. Average Student Response Questionnaire

Analysis of the questionnaire results show that the average student response score was 71%, which is classified as fairly effective. This achivement indicates that the mojority of students responded positively to the implementations of the TAP model combined with snowball media on acid-base material, both in terms of their involvement in learning and their capability to understand the acid-base material. Students activity in learning activities and interaction between groups through the snowball media also strengthened the creation of more collaborative and meaningfull learning. The correlation between student response questionnaire and the improvement in learning outcomes shows that student activity in the plays an improtant aspect in achieving learning outcomes. The aplication of TAP provides opportunities for students to construct arguments logically and systematically, which ultimately helps them to relate concepts more clearly (Widiastiningsih et al., 2022). Meanwhile, the snowball media encourages students to exchange opinions and obtain feedback from their peers (Hariani, 2023).

Several factors can affect the effectiveness of this model. Student characteristics such as general knowledge, motivation, verbal ability and confidence have an impact on their performance in giving arguments (Ayalon, 2024; Lin & Jiao, 2026). In this study, students with higher verbal fluency produced more complete arguments, while students who were initially reserved required more scaffolding before they could formulate warrants or rebuttals. Teacher facilitation also played a significant role, especially in ensuring that snowball questions remained focused on acid-base concepts rather than shifting into unrelated discussions. Managing time for the TAP stages was another factor, as some students needed extra time to construct evidence-based explanations.

Although the TAP-Snowball model has proven effective, its implementation still has some challenges. Students often struggled to generate rebuttals because the skill requires evaluating alternative explanations, which is uncommon in typical chemistry lessons. In larger classes, distributing speaking opportunities evenly was difficult, and more vocal students tended to dominate discussions. Teachers also expressed that preparing valid, concept-oriented snowball questions took additional planning time. Despite these challenges, the combination of cognitive structure (TAP) and social interaction (Snowball) remains an effective learning strategy. The very high Effect Size demonstrates that this model improves not only academic achievement but also communication, critical thinking, and collaboration skills, which are essential for 21st-century education.

CONCLUSION

Drawing upon the findings obtained, it can be inferred that the Toulmin's Argumentation Pattern (TAP) learning model combined with the snowball media on acid-base material is very effective in enhancing student outcomes in learning. This is evidanced by the improvement in student learning outcomes, from an average 7.22 to an average posttest score of 69.16. Than N-Gain test was conducted with a score of 0.67 which indicates a moderate category, and also obtained an effect size value of 4.91 which become part in the very high category. The integration of structured argumentation through TAP with interactive learning using Snowball media encourages students to think critically, communicate scientifically and actively collaborate. This combination creates a learning environment that helps students to connect abstract concepts of chemistry lessons with real context. This leading to deeper understanding and improving student learning outcomes. The novelty of this study lies in the direct integration of snowball media into the TAP argumentative framework, forming an instructional model that simultaneously enhances reasoning and peer interaction. This innovation has not been applied to acid-base learning in previous studies, making the findings valuable in expanding the design of argumentation-based chemistry instruction.

RECOMMENDATIONS

Future studies will include the use of Toulmin's Argumentation Pattern (TAP) technique with Snowball media in learning metrics. Comparison of studies using different learning media may also be carried out to determine its effectiveness in learning. Moreover, creating a scope within cognitive learning results that will target critical thinking skills, skills in arguing, and student motivation will also serve as a means of a follow-up study. By broadening its research range, a greater understanding will be able to assist teachers and students in coping with 21st-century learning challenges.

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