Jurnal Pendidikan MIPA
e-ISSN: 2685-5488 | p-ISSN: 1411-2531
URL: https://jpmipa.fkip.unila.ac.id/index.php/jpmipa
Jounal's DOI: http://doi.org/10.23960/jpmipa

Vol. 27, No. 2, 2026
Article ID: 1295
Pages: 781-800

Enhancing Analytical Thinking and Scientific Attitude: The 7E Learning Cycle with Socio-Scientific Issues Context in Salt Hydrolysis

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Received: 14 February 2026 *Accepted: 17 April 2026* *Published: 01 May 2026*

Abstract: The low level of higher-order thinking skills of students in learning chemistry indicates that students still frequently experience difficulties in developing their thinking abilities. One of the factors is the obstacles in conceptual reasoning and misconceptions experienced by students. These obstacles not only impact the cognitive aspect but are also accompanied by issues in the affective aspect, one of which is a scientific attitude. This serves as an internal factor for establishing optimal learning. One alternative is instruction that uses contexts relevant to daily life, such as implementing the 7E learning cycle model within a socio-scientific issues (SSI) context in learning chemistry. This study aims to examine the effectiveness of the 7E learning cycle model, contextualized with SSI, on students' analytical thinking skills and scientific attitudes regarding salt hydrolysis. The research method used was a quasi-experimental pretest-posttest control group design. The study population included all eleventh-grade students in senior high schools in Madiun City. Sample classes were determined using cluster random sampling, with two experimental and two control classes, for a total of 131 students. The results showed an improvement in students' analytical thinking skills, with an N-Gain score of 0.50, which falls in the medium category, while the improvement in scientific attitude was also in the medium category, with an N-Gain score of 0.35. The MANOVA results showed a significance value of 0.000 < 0.05, indicating a significant difference between the experimental and control groups. The 7E learning cycle, contextualized with SSI, provided a simultaneous, effective contribution of 20.8% to students' analytical thinking skills and scientific attitudes. Based on these findings, it can be concluded that the 7E learning cycle model, contextualized with SSI, has the potential to be more effective in improving students' analytical thinking skills and scientific attitudes regarding salt hydrolysis.

Keywords: 7E learning cycle, socioscientific issues, analytical thinking skills, scientific attitude, salt hydrolysis.

Article's DOI: https://doi.org/10.23960/jpmipa.v27i2.pp781-800

INTRODUCTION

The demands of 21st-century education require a learning system that develops competent, adaptable human resources. The rapid advancement of science and technology necessitates a fundamental transformation in education, particularly in equipping students with essential competencies (Kurniawan, 2025; Malik, 2018; Mardhiyah et al., 2021). Implementing curriculum changes, such as the Merdeka curriculum, is one strategy to develop these competencies. The Merdeka curriculum emphasizes the development of both hard and soft skills, including knowledge, skills, and attitudes (Amiruddin et al., 2023; Rosidin et al., 2025). This aligns with the objectives of chemistry education, which encompass three domains: cognitive, affective, and psychomotor (Wahyudiati, 2022).

Chemistry is the science that studies the structure, properties, and changes of matter through three levels of representation (macroscopic, submicroscopic, and symbolic). Mastery of these three levels of representation is a prerequisite for a thorough understanding of chemical concepts. Chemistry learning is not only for transferring knowledge and skills but also for developing and training higher-level thinking abilities, such as analytical, creative, critical, and innovative thinking (Laliyo et al., 2022). Higher-order thinking skills (HOTS) encompass not only the ability to remember but also to think logically, reflectively, and creatively (Jaenudin et al., 2020). One component of HOTS is analytical thinking, defined as students' ability to differentiate, organize, and identify relationships among concepts to solve complex problems (Fitriyana et al., 2019; Jaenudin et al., 2020). However, various studies indicate that students' analytical thinking skills, particularly in chemistry, remain relatively low. Research by Harta et al. (2020) revealed that analytical thinking skills when working on HOTS questions in chemistry subjects remain relatively low. The mapping analysis of students' analytical thinking abilities showed that students remain weak at distinguishing several basic chemical concepts, have difficulty reorganizing information, and are unable to connect available information to their prior knowledge. Similar findings were reported by Irwanto et al. (2017) and Ad'Hiya & Laksono (2018), who stated that the measurement results for analytical thinking skills on the topics of reaction rates and chemical equilibrium were also relatively low. Meanwhile, measurement results conducted by Arlianty et al. (2018) indicated that the level of C4 thinking or analysis was in the sufficient category. However, this achievement had the lowest percentage among the thinking levels.

The low level of analytical thinking skills can be attributed to factors related to both students and teachers. Student-related factors include unsystematic written responses, answers that merely summarize questions without analysis, misconceptions about the material, and a reliance on memorization rather than conceptual understanding. Teacher-related factors involve problem-solving strategies that do not foster student understanding and the use of unfamiliar problem descriptions (Sarwanto et al., 2021). These conditions suggest that students frequently encounter difficulties in developing their thinking abilities, often due to reasoning challenges and persistent misconceptions (Laliyo et al., 2022). Such difficulties typically arise from inadequate application of conceptual understanding scientifically (Gette et al., 2018). Furthermore, inaccurate interpretations of prior knowledge can lead to misconceptions, which are prevalent in chemistry and pose significant barriers to effective learning (Martin et al., 2001; Üce & Ceyhan, 2019).

One of the materials where students still frequently experience misconceptions is salt hydrolysis. This is evidenced by Prianti et al. (2020), who found misconceptions across all sub-concepts of salt hydrolysis. In the sub-concept of concluding the acid-base properties of salt solutions, misconceptions were experienced by 49.91% of students; in the sub-concept of calculating the pH of salt solutions by 39.15%; analyzing salt hydrolysis reactions by 37.21%; analyzing the concept of hydrolysis occurring in solutions by 35.98%; and in the sub-concept of determining the types of salt hydrolysis by 21.87%. The high percentage of misconceptions in determining acid-base properties and in pH calculations for salt solutions indicates that students have not maximized their prerequisite knowledge before studying salt hydrolysis. This finding aligns with the research results of Shidiq et al. (2019), which revealed that students tend to experience learning difficulties, particularly in interpreting the material and classifying numeracy problems related to salt hydrolysis. One example of a misinterpretation of salt hydrolysis material is that some students still assume that all salt solutions in water have the same pH, namely 7. Furthermore, students often have difficulty determining the acid-base properties of salt solutions using chemical equilibrium concepts and are not yet accurate at writing chemical equations that explain salt hydrolysis. Consequently, these errors directly affect the calculation stage, particularly in predicting the pH of salt solutions (Horvat et al., 2021; Üce & Ceyhan, 2019).

These difficulties and misconceptions are reflected in students' low academic achievement. Interviews with teachers from various schools indicate that average daily test scores remain below the minimum competency criteria. This suggests that students' conceptual understanding of salt hydrolysis is not yet optimal. Effective learning extends beyond information transmission; it is a dynamic, interactive process influenced by multiple internal and external factors (Astuti, 2023; Chen et al., 2023; Ren et al., 2025).

These cognitive problems are apparently aligned with achievements in the students' affective domain. The affective aspect can directly influence academic performance during the learning process (Davut Gül & Ayýk, 2025). One important factor that can influence learning in chemistry is a scientific attitude. The development of students' scientific attitudes can be shaped through the learning process, including participation in experimental activities, discussions, group work, and overall learning (Gading & Rohaeti, 2024). However, in reality, teachers have not fully implemented scientific attitudes in the learning process, such as the application of teacher-centered learning, which causes students to be less effectively involved in the learning process, resulting in students' scientific attitudes remaining low (Andriani & Supiah, 2021; Rohaeti et al., 2020). Furthermore, Fahmidani & Rohaeti (2020) stated that the complex nature of chemical concepts, which are often difficult to explain through analogies and models, is also a factor that requires students to have a strong scientific attitude.

The complexity of the problems, starting from low analytical skills caused by obstacles in reasoning concepts and misconceptions, to the affective aspect, namely scientific attitude, which plays a role as an internal factor in building optimal learning, indicates the need for an approach that not only teaches concepts but also involves students in developing their thinking abilities. One approach is to raise the context of social issues related to science, also known as socio-scientific issues. SSI refers to the context in which science is applied to complex real-world problems (Högström et al., 2024). Socio-scientific issues contain current science contexts that consider various dimensions (social, economic, religious, ethical, health, science, and technology) (Sadler & Zeidler, 2005). The SSI context provides meaningful learning experiences to develop problem-solving skills and connect concepts, thereby enhancing cognitive processes (Zamakhsyari & Rahayu, 2020). The use of SSI-contextualized learning in the classroom can help students improve their understanding of the social implications of science and how science is viewed by social values. Contextual learning provides opportunities for students to critically analyze information, reason, and integrate prior knowledge to make appropriate decisions (Herman et al., 2021; Tsai, 2018). Thus, SSI can play an effective role in integrating salt hydrolysis material into meaningful chemistry learning.

Learning in the SSI context can be implemented through constructivist models, such as the learning cycle. The learning cycle model is student-centered, allowing students to actively explore their understanding of the material, thereby optimizing learning outcomes. This aligns with the principles of constructivism, which emphasize students' active construction of their own knowledge (Do et al., 2023; Marfilinda et al., 2019). One development of this model is the 7E learning cycle (Whudian et al., 2023). Through this model, students are given space to independently discover and understand the concepts being studied, so their understanding deepens as the concepts are self-constructed through the learning process (Marfilinda et al., 2019; Wibowo & Suyanta, 2019). The learning approach in this course can shape students' thinking patterns to be more systematic and structured, making it easier for them to understand and remember chemistry material linked to everyday life. The 7E learning cycle model is identified as one of the constructivist approaches that aligns with learning principles considering students' developmental levels, as it allows them to use prior knowledge as a foundation for learning new thought processes, developing higher-order thinking skills, and increasing awareness of their own reasoning (Mekonnen et al., 2024; Nurlatifah et al., 2018; Wodaj & Belay, 2021). The abstract nature of the salt hydrolysis topic, along with its numerous mathematical calculations and equilibrium concepts, requires an approach that bridges theoretical understanding and real-world applications. Therefore, the 7E learning cycle instruction within a socio-scientific issues (SSI) context can serve as an alternative to enhance students' analytical thinking abilities and scientific attitudes regarding salt hydrolysis. Based on the explanation above, this research is designed to answer the following research questions:

RQ 1: Is there a significant simultaneous difference in analytical thinking skills and scientific attitudes between students taught using the 7E learning cycle with SSI context and students taught using guided inquiry?
RQ 2: Is there a significant difference in analytical thinking skills between the two groups?
RQ 3: Is there a significant difference in scientific attitudes between the two groups?

■ METHOD

Participants

This study involved eleventh-grade students from two public senior high schools in Madiun. School selection was carried out based on the criteria: the school is accredited A, has implemented the Merdeka Curriculum, has good facilities and infrastructure (such as laboratory facilities and internet access), and teaches salt hydrolysis material in grade XI. The population of this study was all grade XI students with relatively similar characteristics. The research sample was selected using a cluster random sampling technique on intact classes from each school, yielding two experimental classes and two control classes, with an average of 32–36 students per class. Before treatment, students' initial abilities were tested using ANOVA, and the results showed no significant difference between classes (homogeneous).

Research Design and Procedures

This study used a quasi-experimental pre-post control-group design. The sample used in this study was 131 students from 11th-grade public high schools in Madiun City. The experimental group implemented the 7E learning cycle model with the SSI context. In contrast, the control group implemented the guided inquiry model, which is commonly used in learning, based on interviews with teachers at the schools. The application of the guided inquiry model is effective in developing students' ability to think and analyze problems (Orosz et al., 2022). However, guided inquiry has distinct characteristics compared to the 7E learning cycle, particularly in how its instructional stages are implemented.

Learning activities in the experimental class used SSI contexts relevant to salt hydrolysis. Meanwhile, learning activities in the control class applied the guided inquiry syntax, namely orientation, problem identification, hypothesis formulation, data collection, data analysis, and conclusions (Banerjee, 2010; Lazonder & Harmsen, 2016; Wen et al., 2020). Both classes used the same learning media, namely student worksheets (LKPD), covering two sub-topics: the concept of salt hydrolysis and the types of salt hydrolysis. Technically, the research implementation was divided into three stages. The first meeting began with a pretest and a questionnaire (45 minutes), followed by a discussion on the basic concepts of hydrolysis. In the second meeting (3 x 45 minutes), students explored the types of salt hydrolysis through a 90-minute core activity based on the syntax of their respective learning models. The remaining instructional time was allocated to the evaluate-and-extend phases in the experimental class and to drawing conclusions and reflection in the control class. During the learning process, an observer monitored changes in students' scientific attitudes. After the learning implementation was completed, students were given a posttest consisting of a written test and a questionnaire similar to the pretest to evaluate the development of their analytical thinking skills and scientific attitudes. Based on the collected pretest and posttest results, the improvement in students' analytical thinking skills and scientific attitudes toward the salt hydrolysis material could be quantitatively compared and measured.

Instrument

The instruments used in this study consisted of an analytical thinking skills test developed from aspects of Anderson et al. (2001), namely, differentiating, organizing, and attributing (connecting). For the differentiating aspect, the developed question indicators included students' ability to distinguish the properties of salt solutions, categorize types of salts (total hydrolysis, partial hydrolysis, or no hydrolysis), and identify the acids and bases that form the salts. For the organizing aspect, students were directed to formulate salt hydrolysis reaction equations and determine mathematical solutions for pH values, hydrolysis constants, and related calculations. Meanwhile, for the connecting aspect, students were expected to be able to relate the influence of salt solutions in various given question contexts. One example of a question developed based on the organizing aspect of analytical thinking involves linking the high sodium content of sodium carbonate in instant noodles to the risk of triggering hypertension and subsequent kidney damage if consumed excessively. This premise can be used to determine the hydrolysis reaction equation for sodium carbonate and to calculate the solution's pH, provided that its molarity and acid dissociation constant are known. The selection of a socio-scientific issue (SSI) context, such as the consumption of instant noodles, represents a form of instrument adaptation to the daily habits and culture of Indonesian society. This approach ensures that the problems presented are more familiar, relevant, and easily comprehensible to students.

The scientific attitude questionnaire was adapted from previous studies, including those by Fatonah et al. (2023), Misbah et al. (2018), Rampean et al. (2021), and Supardi et al. (2019). The aspects of scientific attitude used in the adaptation are curiosity, honesty, critical thinking, open-mindedness, cooperation, and responsibility. These aspects were developed into indicators for the questionnaire and observation sheets to monitor changes in students' attitudes during the learning process. The instrument adaptation process involved restructuring the statements into standard, communicative Indonesian and aligning the indicators with the character values emphasized in the Indonesian curriculum and educational environment. For instance, an indicator of the adapted aspect of curiosity is that students demonstrate attention and enthusiasm during learning activities. The questionnaire items consist of both positive and negative statements, evaluated using a five-point Likert scale: strongly agree, agree, neutral, disagree, and strongly disagree.

Both instruments were validated by experts to ensure their relevance to classroom instructional activities. The expert validators comprised two chemistry education lecturers from Universitas Negeri Yogyakarta (UNY). Subsequently, empirical validation was conducted using the Rasch model assisted by the Winsteps software. Validity was determined based on item fit as measured by Outfit MNSQ, Outfit ZSTD, and Pt-Measure Corr (Boone et al., 2014). Item validity was determined based on its conformity with the criteria: (1) Outfit MNSQ value between 0.5 < MNSQ < 1.5; (2) Outfit ZSTD value between -2.0 < ZSTD < +2.0; and (3) Point Measure Correlation value between 0.4 < Pt Measure Corr < 0.85. The validation results for the analytical thinking skills test showed that 12 essay questions could be used in the study, with a high reliability of 0.93. Meanwhile, for the scientific attitude questionnaire, 11 statements could not be used because they did not meet the validity requirements across the three criteria. The reliability of the scientific attitude questionnaire was high, with a Cronbach's alpha of 0.94. This indicates that both instruments are highly consistent in measuring students' analytical thinking skills and scientific attitudes.

Data Analysis

Data for this research were collected through tests, questionnaires, and observation sheets. The data analysis technique used is the parametric statistical test MANOVA. This test determines whether there is a significant difference between students who apply the 7E learning cycle in an SSI context and those who apply guided inquiry learning, with the control variable held constant and tested separately. Next, the between-subjects test is used to determine the effective contribution of learning to analytical thinking skills and scientific attitude, both simultaneously and individually. All these tests were conducted after meeting the prerequisite tests, which included tests for univariate and multivariate outliers, normality, homogeneity of variance-covariance matrices, linearity, and multicollinearity. This test was conducted with the assistance of SPSS version 25.

RESULT AND DISCUSSION

Data analysis was conducted using MANOVA assumption tests. According to Hair et al. (2014), before using MANOVA, prerequisite tests must be performed. The test results showed that all required assumptions were met, namely: (1) dependent variables were measured on an interval scale; (2) independent variable consisted of two or more categories; (3) sampling was done independently, meaning there was no relationship between groups or between members within each group; (4) the sample size was adequate, totaling 131 students; (5) there were no univariate or multivariate outliers (1 outlier was found in the experimental group and 4 outliers in the control group, so all outliers were removed from further analysis); 6) data were normally distributed based on the Shapiro-Wilk test ($p > 0.05$); 7) there was a linear relationship between each pair of variables ($p > 0.05$); 8) the variance-covariance matrices were homogeneous based on Box's M test ($p = 0.333$); 9) no multicollinearity was indicated by Tolerance value = 0.804 and VIF = 1.244. Additionally, the correlation between the dependent variables was 0.516, which falls in the medium range. With all these assumptions met, MANOVA analysis was continued using Hotelling's Trace statistic.

RQ1: Simultaneous Difference in Students' Analytical Thinking Skills and Scientific Attitudes between the Application of the 7E Learning Cycle with SSI Context and Students Following Guided Inquiry Learning

Implementing the 7E learning cycle in the SSI context improved students' analytical thinking skills and scientific attitudes in both the experimental and control groups. This improvement is shown through the N-gain values obtained from the pre-test and post-test results by indicator, as presented in Tables 1, 2, 3, and 4.

Table 1. N-gain result of analytical thinking skill by indicator for the control group

Value	Aspect		
	Differentiating	Organizing	Connecting
Mean Pretest	149.0	128.8	194.7
Mean Postest	207.3	198.4	206.7
N-Gain	0.507	0.515	0.173

Table 2. N-gain result of analytical thinking skill by indicator for the experiment group

Value	Aspect		
	Differentiating	Organizing	Differentiating
Mean Pretest	152.25	127.00	194.33
Mean Postest	215.25	203.60	211.67
N-Gain	0.585	0.576	0.264

Table 3. N-gain result of scientific attitude by indicator for the control group

Value	Aspect					
	Curiosity	Honesty	Critical Thinking	Open-Mindedness	Cooperation	Responsibility
Mean Pretest	205.63	204.50	202.00	213.75	216.00	250.00
Mean Postest	245.38	250.00	248.67	248.25	242.25	267.00
N-Gain	0.320	0.363	0.365	0.297	0.230	0.213

Table 4. N-gain result of scientific attitude by indicator for the experiment group

Value	Aspect					
	Curiosity	Honesty	Critical Thinking	Open-Mindedness	Cooperation	Responsibility
Mean Pretest	226.38	217.50	210.67	241.50	225.67	240.00
Mean Postest	250.00	254.00	255.33	271.25	272.00	274.00
N-Gain	0.240	0.340	0.391	0.356	0.466	0.400

The data analysis revealed that both groups increased their scores from the pretest to the posttest. However, the N-gain scores of the experimental group were superior to those of the control group across most indicators of analytical thinking skills and scientific attitude. This indicates that implementing the 7E learning cycle model contextualized with SSI is more effective than the guided inquiry model. The superior performance of the experimental group is also clearly evident in the scatter plots shown in Figures 1 and 2. This result is supported by the MANOVA test with a Sig. value of 0.000 < 0.05, thus H_0 is rejected. The MANOVA results indicate a significant simultaneous difference in analytical thinking skills and scientific attitudes between students in the experimental and control groups. The effective contribution of the 7E learning cycle in an SSI context can be determined by the partial eta-squared value of 0.208 (20.8%), which indicates a high category.

The learning cycle model emphasizes the active role of students (student-centered). This model highlights students' actions in the classroom, thereby fostering a series of cognitive activities that influence their thinking patterns. Active collaborative engagement develops the ability to examine information contexts, solve problems, connect problems to concepts, and arrive at appropriate answers. The 7E learning

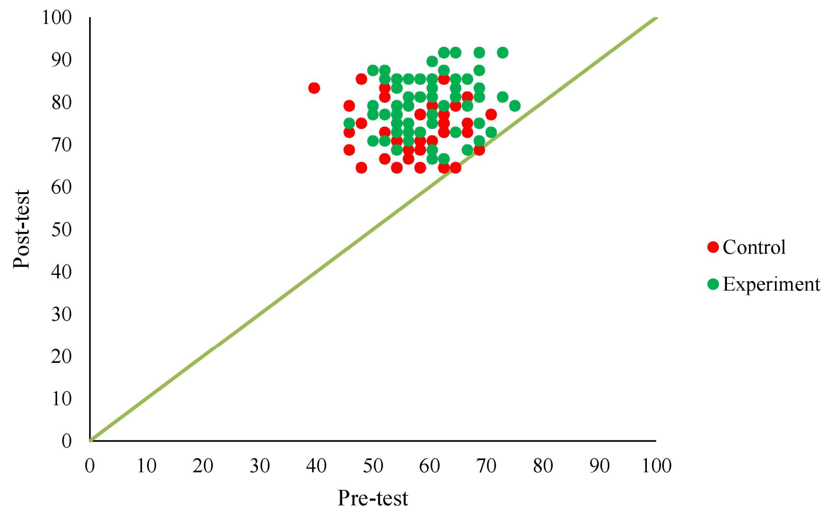


Figure 1. Scatter plot of pre-post scores of analytical thinking

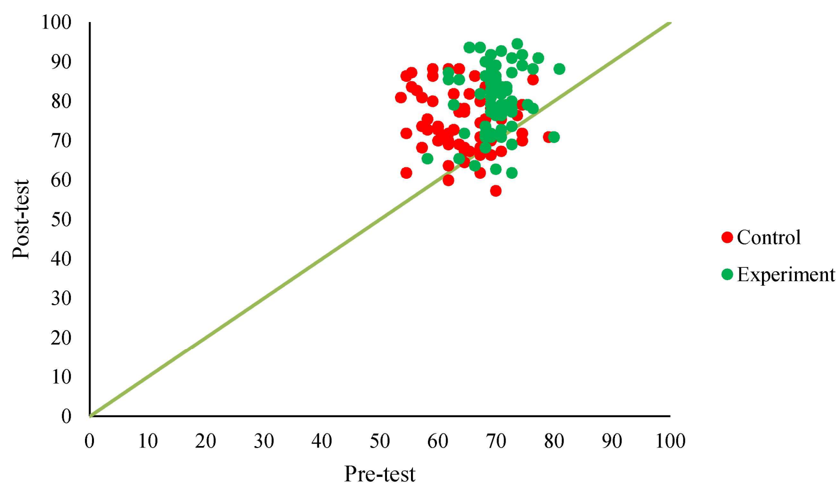


Figure 2. Scatter plot of pre-post scores of scientific attitude

cycle, based on a constructivist approach, has structured, comprehensive phases that encourage students' participation in discovering and understanding concepts (Perdana et al., 2024).

The use of the SSI context in this learning strengthens the development of higher-order thinking, particularly analytical thinking skills. The SSI context aims to connect learning activities with the application of the material to relevant real-life issues. SSI-based learning involves scientific understanding to view social issues from multiple dimensions, addressing complex problems and requiring students to consider the ethical, economic, social, and environmental aspects of an issue (Zeidler & Keefer, 2003). This encourages students to collaborate to reach a mutual agreement, with the teacher acting as a facilitator who guides them in discovering the relationship between social issues and the material (Carlson, 2015; Ke et al., 2020).

RQ2: Difference in Analytical Thinking Skills between Experimental Group and Control Group

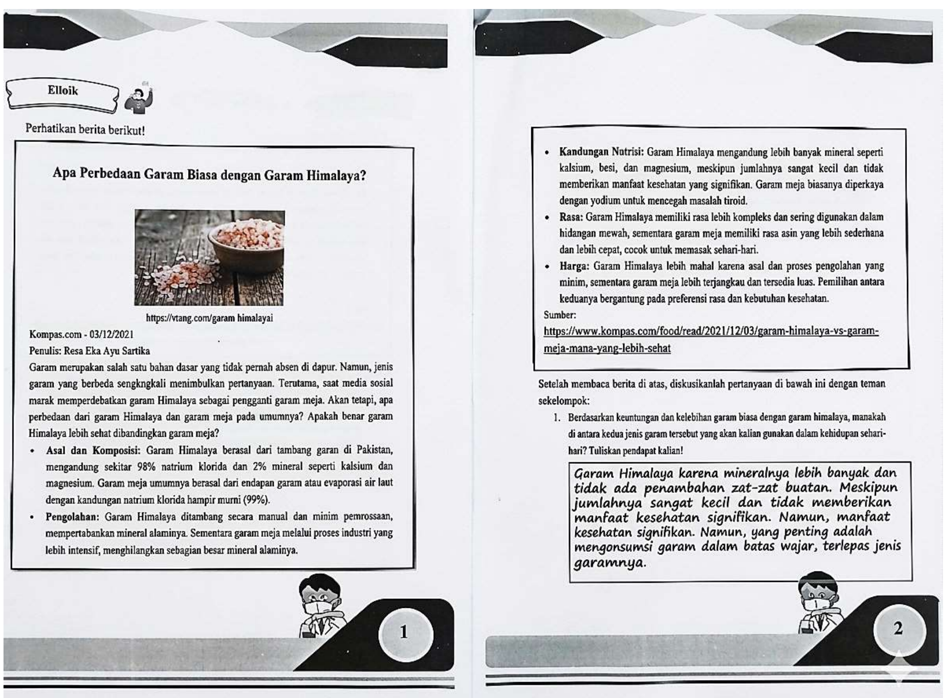
The difference in analytical thinking skills between the experimental and control groups is shown in Table 5.

Table 5. Test of between-subject effect results

Dependent Variables	F	*Sig.*	*Partial Eta Squared*
Analytical Thinking Ability	31.249	0.000	0.195

Based on Table 5, the Sig. value for analytical thinking skills (0.000 < 0.05) indicates that H_0 is rejected. This confirms a significant difference in analytical thinking skills between students who applied the 7E learning cycle with the SSI context and those who applied guided inquiry learning. The effective contribution of the 7E learning cycle to analytical thinking ability in the SSI context was 20.8%, in the high category. Further analysis of the post-test scores shows that the experimental group's score was higher than the control group's. This finding aligns with Yennita et al. (2023), who stated that the 7E learning cycle enhances higher-order thinking skills, particularly the analysis component, by emphasizing understanding phenomena, building fact-based arguments, and providing solutions. Additionally, Dusturi et al. (2024) found that the SSI approach improved critical thinking skills, with the highest scores observed in question analysis.

The application of this model is effective in training analytical thinking skills through information processing in a collaborative learning environment. Group discussions familiarize students with expressing arguments and solutions. Increased cognitive ability occurs because students are active at every stage (elicit, engage, explore, explain, elaborate, extend, and evaluate) (Musfiroh et al., 2024). Learning begins by eliciting students' prior knowledge through triggering questions or small-group discussions that present SSI problems, as shown in Figure 3.


Elloik

Perhatikan berita berikut!

Apa Perbedaan Garam Biasa dengan Garam Himalaya?

https://vtang.com/garam himalayai

Kompas.com - 03/12/2021

Penulis: Resa Eka Ayu Sartika

Garam merupakan salah satu bahan dasar yang tidak pernah absen di dapur. Namun, jenis garam yang berbeda sengkngkali menimbulkan pertanyaan. Terutama, saat media sosial marak memperdebatkan garam Himalaya sebagai pengganti garam meja. Akan tetapi, apa perbedaan dari garam Himalaya dan garam meja pada umumnya? Apakah benar garam Himalaya lebih sehat dibandingkan garam meja?

- **Asal dan Komposisi:** Garam Himalaya berasal dari tambang garan di Pakistan, mengandung sekitar 98% natrium klorida dan 2% mineral seperti kalsium dan magnesium. Garam meja umumnya berasal dari endapan garam atau evaporasi air laut dengan kandungan natrium klorida hampir murni (99%).
- **Pengolahan:** Garam Himalaya ditambang secara manual dan minim pemrossaan, mempertabankan mineral alaminya. Sementara garam meja melalui proses industri yang lebih intensif, menghilangkan sebagian besar mineral alaminya.

1

- **Kandungan Nutrisi:** Garam Himalaya mengandung lebih banyak mineral seperti kalsium, besi, dan magnesium, meskipun jumlahnya sangat kecil dan tidak memberikan manfaat kesehatan yang signifikan. Garam meja biasanya diperkaya dengan yodium untuk mencegah masalah tiroid.
- **Rasa:** Garam Himalaya memiliki rasa lebih kompleks dan sering digunakan dalam hidangan mewah, sementara garam meja memiliki rasa asin yang lebih sederhana dan lebih cepat, cocok untuk memasak sehari-hari.
- **Harga:** Garam Himalaya lebih mahal karena asal dan proses pengolahan yang minim, sementara garam meja lebih terjangkau dan tersedia luas. Pemilihan antara keduanya bergantung pada preferensi rasa dan kebutuhan kesehatan.

Sumber:
https://www.kompas.com/food/read/2021/12/03/garam-himalaya-vs-garam-meja-mana-yang-lebih-sehat

Setelah membaca berita di atas, diskusikanlah pertanyaan di bawah ini dengan teman sekelompok:

1. Berdasarkan keuntungan dan kelebihan garam biasa dengan garam himalaya, manakah di antara kedua jenis garam tersebut yang akan kalian gunakan dalam kehidupan sehari-hari? Tuliskan pendapat kalian!

Garam Himalaya karena mineralnya lebih banyak dan tidak ada penambahan zat-zat buatan. Meskipun jumlahnya sangat kecil dan tidak memberikan manfaat kesehatan signifikan. Namun, manfaat kesehatan signifikan. Namun, yang penting adalah mengonsumsi garam dalam batas wajar, terlepas jenis garamnya.

2

Figure 3. Elicitation activities using the SSI context

The elicit and engage phase evokes prerequisite knowledge and enthusiasm through SSI contexts (such as comparing Himalayan salt with regular salt, and soap waste from laundry businesses in rivers) and group discussions (Mustafa & Suyanta, 2019). The selection of these SSI contexts is based on surrounding issues; for example, the use of Himalayan salt vs. regular salt can be discussed from health and economic perspectives, which will generate differing opinions among students. This SSI context encourages students to consider various perspectives (Herman et al., 2021; Ke et al., 2020; Sadler, 2004). In the explore phase, students connect problems with concepts through worksheets, independently practicing information analysis (Noreen et al., 2024; Udonsathian & Worapun, 2024). The explain phase involves students presenting discussion results and the teacher clarifying concepts (Marfilinda et al., 2019; Noreen et al., 2024). The elaboration phase applies concepts across different contexts to sharpen information-organization skills (Ramadani et al., 2021). The evaluation phase assesses understanding through tests that measure the ability to differentiate, organize, and connect concepts (Noreen et al., 2024). The extend phase encourages knowledge transfer to new situations for long-term retention (Karenina et al., 2020; Muthma'Innah et al., 2019). This model allows for collaborative problem-solving that develops critical thinking skills (Suardana et al., 2018). Guided inquiry tends to be less supportive of the transfer of new context and makes it difficult to formulate hypotheses due to a lack of prerequisite knowledge (Febri et al., 2020; Orosz et al., 2022). Conversely, the SSI context enhances analytical, critical, and reflective thinking by considering various aspects of phenomena, interactive communication, and the construction of meaningful arguments (Blegur et al., 2023; Gul & Akcay, 2020; Kusumaningrum et al., 2021; Rahman & Chavhan, 2022; Solbes et al., 2018; Suryawati & Osman, 2018).

The use of guided inquiry learning and the 7E learning cycle with the SSI context both yielded N-gain values in the medium category. This indicates that using both learning models yields a significant improvement; however, a fundamental syntactic difference affects the post-test results. Guided inquiry learning begins with problem investigation, identification, and hypothesis formulation, steps requiring higher-order thinking skills. However, students often have difficulty formulating hypotheses because it requires mastery of prerequisite material (acid-base); this lack of prior knowledge hinders their ability to analyze data and draw conclusions (Orosz et al., 2022). Furthermore, guided inquiry does not explicitly direct students to apply knowledge from experiments to new contexts, making it difficult for them to transfer the understanding they have acquired (Orosz et al., 2022). Meanwhile, the use of the SSI context also encourages students to develop their analytical thinking skills better. Research results from Solbes et al. (2018) indicate that using the SSI context in learning can help students develop critical thinking because the social-interactive process encourages communication to express thoughts and questions and provides responsibility for thinking when articulating ideas, beliefs, and concepts. This supports students in forming well-reasoned opinions, connecting concepts with real-world problem contexts, and making the learning of scientific concepts more meaningful. Contextual learning can help students build networks, organize concepts within their cognitive domain, and develop higher-order thinking skills, including analytical thinking (Blegur et al., 2023; Suryawati & Osman, 2018).

Further analysis of analytical thinking ability was conducted based on the aspects of differentiating, organizing, and connecting. The

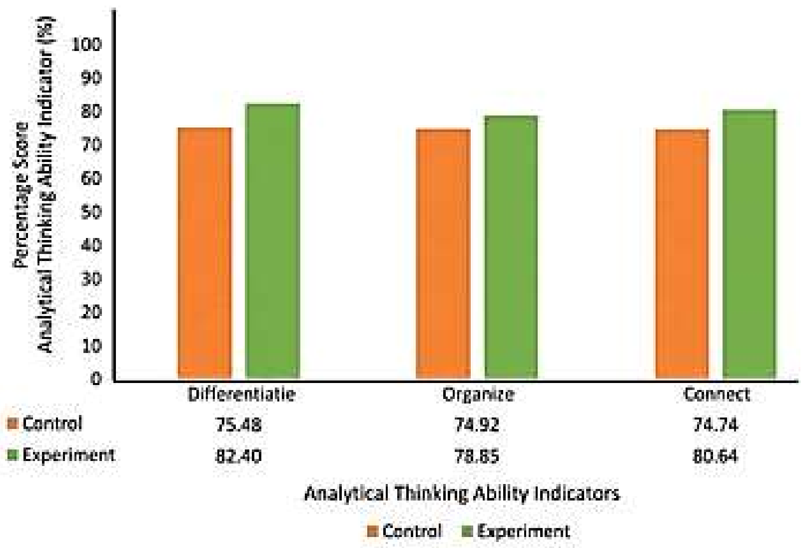


Figure 4. Analytical thinking skills following participation in LC 7E in the context of SSI

average score details for each aspect in the experimental and control groups are elaborated in Figure 4. The highest result was in the distinguishing aspect, with 82.40 for the experimental group and 75.48 for the control group. The high scores on the distinguishing aspect in the experimental group are due to the implementation of learning approaches that train students to break down complex and controversial information into authentic, multidimensional problems (Owens & Sadler, 2024; Zeidler et al., 2019). In the explore and explain phase, students are encouraged to seek and evaluate diverse information, thereby practicing their ability to distinguish between objective scientific facts and subjective opinions, between relevant and irrelevant information, and between scientific claims and ethical considerations (Anderson et al., 2001). This high score indicates that the students in the experimental group are accustomed to dealing with complex, multi-perspective data, which aligns with Prastika and Arianingrum (2025). Conversely, the control group with a procedural approach is more focused on understanding structured concepts, making them less prepared to face ambiguous dilemmas. The organizing aspect has a lower score (78.85%) because some students still struggle to explain a systematic sequence of steps, such as calculating the pH of salt hydrolysis, due to a tendency to apply formulas without fully understanding the underlying concepts. This was because students needed to be reminded of their prerequisite understanding, especially of the stoichiometry material, and, due to the limited time available for the research implementation, the classroom learning process was less than optimal.

RQ3: Difference in Scientific Attitude between Experimental Group and Control Group

The difference in scientific attitude between the experimental and control groups can be shown in Table 6

Table 6. Test of between-subject effect results

Dependent Variables	F	*Sig.*	*Partial Eta Squared*
Scientific Attitude	12.721	0.001	0.090

Based on Table 6, the Sig. value for scientific attitude (0.001 < 0.05) indicates that H_0 is rejected. This confirms a significant difference in scientific attitude between students who applied the 7E learning cycle with the SSI context and those who applied guided inquiry learning. This finding is further supported by the post-test scores, in which the experimental group achieved higher results than the control group. The model's effectiveness on scientific attitudes is reflected in a partial eta squared of 0.090 (9.0% contribution), which, although categorized as moderate, statistically demonstrates its superiority over guided inquiry. This outcome may be attributed to several factors, including students' initial unfamiliarity with the 7E learning cycle and internal factors related to individual differences in interest (Madina, 2024; Osborne et al., 2003)

This aligns with the findings of Puspita et al. (2018) and Sugrah et al. (2023) that the 7E learning cycle and SSI-based learning can enhance students' scientific attitudes. This is because the 7E learning cycle encourages students to respond to the material being taught. Additionally, the SSI issues used provide students with opportunities to exchange ideas, evaluate, reflect, and draw conclusions from various arguments. Small-group discussions among students can foster open-mindedness and curiosity by encouraging students to listen to one another's arguments and collaborate to reach conclusions. Learning experiences using real-world topics or problems provide opportunities for students to develop critical thinking, communication, collaboration, and reflection (Lowell & Moore, 2020). This process can shape students' scientific attitudes, which can be reviewed from various aspects.

The differences in the effectiveness of the learning model implementation stem from differences in steps and context. The SSI context places students in a learning process that involves complex issues, such as MSG use, sodium in instant noodles, or the impact of water waste from soap use. This context not only demands understanding of scientific concepts but also involves ethical considerations, empathy, and argumentation skills in facing social dilemmas (Zeidler et al., 2019). This process naturally fosters scientific attitudes, such as honesty, open-mindedness, and critical thinking skills. The SSI context, supported by learning steps that prioritize group work, enables the 7E learning cycle to elicit scientific attitudes across its syntaxes (Puspita et al., 2018; Zeidler et al., 2019).

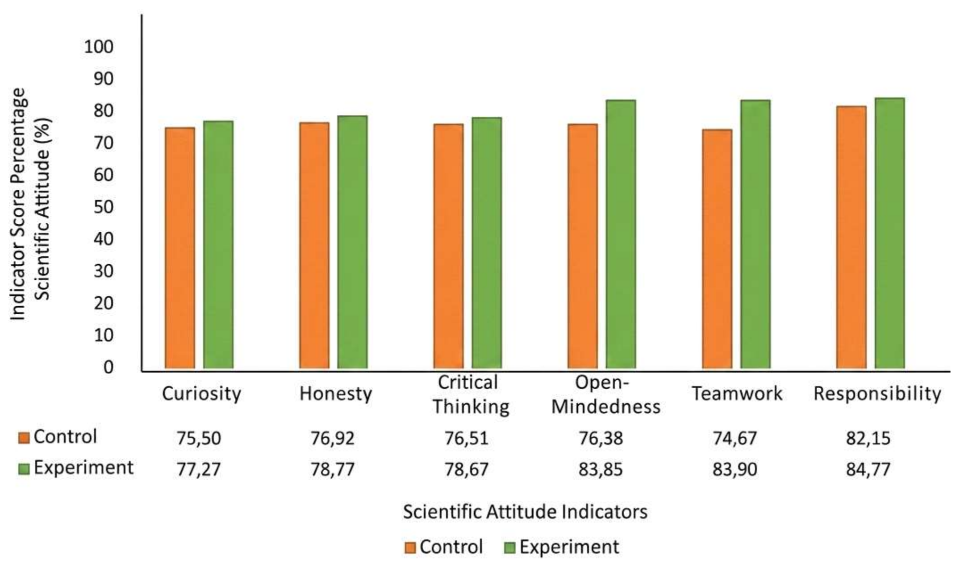


Figure 5. Scientific attitude following participation in LC 7E in the context of SSI

Further analysis of scientific attitudes was conducted using indicators of curiosity, honesty, critical thinking, open-mindedness, cooperation, and responsibility, with the results shown in Figure 5. The highest scores were obtained for the indicators of responsibility (84.77), cooperation (83.90), and open-mindedness (83.85). Observations show that these three indicators are better in the experimental group. These findings indicate that SSI-contextualized learning cycle 7E learning is more effective in positively influencing scientific attitudes, particularly responsibility, aligning with Febriani & Singasari (2020), Sugrah et al. (2023), and Uyank (2016). Differences in scientific attitude profiles between groups are caused by the learning model used. The 7E learning cycle enhances scientific attitudes through structured steps and small group discussions at each phase (Puspita et al., 2018). In the experimental class, the discussion dynamics were more complex, as students were tasked with dissecting socio-scientific issues (SSI) dilemmas, which demanded intensive collaboration, including task delegation, constructive debate, and the synthesis of findings. For instance, the implementation of SSI was contextualized by comparing the use of Himalayan salt and conventional salt from both economic and health perspectives. This contextual issue proved effective in stimulating open-mindedness and group collaboration in formulating arguments on the student worksheets. Furthermore, the examination of detergent waste from laundry businesses was introduced to spark students' critical thinking and curiosity regarding environmental pollution, while simultaneously balancing economic considerations and proposing alternative solutions. The integration of diverse SSI contexts across the instructional phases familiarized students with analytical argumentation in problem-solving. Conversely, discussions in the control group were strictly centered on solving conceptual problems tied to the textual materials. This discrepancy in the characteristics of the learning activities accounted for the differences in scientific attitude outcomes between the control and experimental groups. Consequently, the 7E learning cycle model served as a formal framework for collaboration, while the SSI context provided an authentic urgency for effective cooperation (Sadler, 2009).

CONCLUSION

Based on the research findings, it can be concluded that there is a significant difference, both simultaneously and individually, in analytical thinking skill and scientific attitude between students who participated in learning cycle 7E contextualized with Socio-Scientific Issues (SSI) and students who used a guided inquiry model on the topic of salt hydrolysis. The 7E learning cycle with SSI context provided a highly effective contribution to both variables, at 20.8%. These results suggest that the 7E learning cycle with an SSI context may be more effective in developing students' analytical thinking skills and scientific attitudes. Therefore, this model is recommended as an innovative alternative instructional approach, particularly for salt hydrolysis, to support the attainment of 21st-century competencies. Furthermore, from a theoretical perspective, these findings demonstrate that integrating socio-scientific issues effectively bridges the gap between abstract chemical concepts and real-world phenomena.

However, this study has limitations regarding the sampling procedure. The randomization was conducted using intact classes (cluster random sampling) rather than individual randomization, as the students were already assigned to pre-existing classes. However, the selection of the school serving as the research location was strictly guided by predetermined criteria. Additionally, technical constraints, such as limited time and inconsistent student attendance due to conflicting school schedules, slightly hindered the optimal implementation of each instructional stage in the classroom.

To address these limitations, future research implementing this model should ensure a sufficient time allocation so that each instructional stage can be executed effectively to produce optimal results. Additionally, future studies are recommended to integrate the 7E-SSI learning cycle with the STEM framework or Education for Sustainable Development (ESD). This approach would allow students not only to analyze socio-scientific dilemmas but also to design concrete, sustainable technological solutions to real-world environmental issues.

DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the writing of this manuscript, the authors employed Grammarly to assist with language refinement and grammatical correction. The authors have reviewed and edited the content generated by this tool and assume full responsibility for the content of the published article.

REFERENCES

Ad'Hiya, E., & Laksono, E. W. (2018). Students' analytical thinking skills and chemical literacy concerning chemical equilibrium. *AIP Conference Proceedings* , 1–5. https://doi.org/10.1063/1.5062824

Amiruddin, Baharuddin, F. R., Takbir, & Setialaksana, W. (2023). May student-centered principles affect active learning and its counterpart? An empirical study of Indonesian curriculum implementation. *SAGE Open*, *13*(4), 1–16. https://doi.org/10.1177/21582440231214375

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing/ : A revision of Bloom's taxonomy of educational objective*. Addison Wesley Longman Inc.

Andriani, R., & Supiah, Y. L. I. (2021). Effect of problem based learning models on students' analytical thinking abilities and scientific attitudes in chemistry. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012190

Arlianty, W. N., Febriana, B. W., Diniaty, A., & Fauzi'ah, L. (2018). Student profile in completing questions based on cognitive level of bloom's taxonomy by Anderson and Krathwohl. *AIP Conference Proceedings*, *2026*(1), 20063. https://doi.org/10.1063/1.5065023

Astuti, R. T. (2023). *Profil Kesulitan Belajar Peserta Didik dalam Memahami Materi Hidrolisis Garam* [Profile of Students' Learning Difficulties in Understanding Salt Hydrolysis Material. *ORBITAL: Jurnal Pendidikan Kimia*, *6*(2), 250–261.

Banerjee, A. (2010). Teaching science using guided inquiry as the central theme/ : A professional development model for high school science teachers. *Science Educator*, *19*(2), 1–9.

Blegur, J., Rajagukguk, C. P. M., Sjioen, A. E., & Souisa, M. (2023). Innovation of analytical thinking skills instrument for throwing and catching game activities for elementary school students. *International Journal of Instruction*, *16*(1), 723–740. https://doi.org/10.29333/iji.2023.16140a

Carlson, J. (2015). Learning Cycle. In *Encyclopedia of Science Education* (pp. 584–588). Springer Science+Business Media Dordrecht. https://doi.org/10.1007/978-3-030-10576-1_211

Chen, D. P., Chang, S. W., Burgess, A., Tang, B., Tsao, K. C., Shen, C. R., & Chang, P. Y. (2023). Exploration of the external and internal factors that affected learning effectiveness for the students: a questionnaire survey. *BMC Medical Education*, *23*(1), 1–7. https://doi.org/10.1186/s12909-023-04035-4

Davut Gül, M., & Ayýk, Z. (2025). Impacts of enrichment programs on cognitive and affective skills of gifted students: A meta-analysis. *Plos One*, *20*(10 October), 1–21. https://doi.org/10.1371/journal.pone.0333714

Do, H. N., Do, B. N., & Nguyen, M. H. (2023). How do constructivism learning environments generate better motivation and learning strategies? The Design Science Approach. *Heliyon*, *9*(12), e22862. https://doi.org/10.1016/j.heliyon.2023.e22862

Dusturi, N., Nurohman, S., & Wilujeng, I. (2024). Socio-scientific issues (SSI) approach implementation in science learning to improve students' critical thinking skills: Systematic literature review. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 149–157. https://doi.org/10.29303/jppipa.v10i3.6012

Fahmidani, Y., & Rohaeti, E. (2020). Attitude toward chemistry: Student's perception based on learning experience. *Journal of Physics: Conference Series*, *1440*(1), 12016. https://doi.org/10.1088/1742-6596/1440/1/012016

Fatonah, S., Prasetyo, Z. K., Utami, A. D., Chasanah, U., Lusiana, L., & Siregar, V. V. (2023). Scientific attitude and its effect on students' productivity. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 658–671. https://doi.org/10.15294/jpii.v12i4.47727

Febri, A., Sarwanto, & Rahardjo, D. T. (2020). *Pengaruh eksperimentasi inkuiri terbimbing (guided inquiry) dan learning cycle 7E pada pembelajaran fisika terhadap kemampuan kognitif ditinjau dari motivasi belajar siswa di SMA* [The influence of guided inquiry experimentation and the 7E learning cycle on physics learning on cognitive abilities as viewed from the perspective of student learning motivation in high school]. *Jurnal Sains Edukatika Indonesia (JSEI)*, *2*(1), 5–13.

Febriani, F., & Singasari, M. I. M. (2020). *Peningkatan sikap tanggung jawab dan prestasi belajar melalui model pembelajaran kolaboratif tipe cycle 7E* [Improving the attitude of responsibility and learning achievement through the collaborative learning model of the 7E cycle type]. *Premiere Educandum: Jurnal Pendidikan Dasar Dan Pembelajaran*, *10*(2), 175–186. https://doi.org/10.25273/pe.v10i2.6335

Fitriyana, N., Marfuatun, M., & Priyambodo, E. (2019). The Profile of Students' Analytical Thinking Skills on Chemistry Systemic Learning Approach. *Scientiae Educatia*, *8*(2), 207. https://doi.org/10.24235/sc.educatia.v8i2.5272

Gading, R. M. A. D. P., & Rohaeti, E. (2024). Developing an instrument for scientific attitude assessment in learning chemistry. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1039–1047. https://doi.org/10.29303/jppipa.v10i3.6669

Gette, C. R., Kryjevskaia, M., Stetzer, M. R., & Heron, P. R. L. (2018). Probing student reasoning approaches through the lens of dual-process theories: A case study in buoyancy. *Physical Review Physics Education Research*, *14*(1), 10113. https://doi.org/10.1103/PhysRevPhysEducRes.14.010113

Gul, M. D., & Akcay, H. (2020). Structuring a new socioscientific issues (SSI) based instruction model: impacts on pre-service science teachers' (PSTs) critical thinking skills and dispositions. *International Journal of Research in Education and Science (IJRES)*, *6*(1), 141–159.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Multivariate data analysis. In *Pearson Education*. https://doi.org/10.4324/9781351269360

Harta, J., Rasuh, N. T., & Seriang, A. (2020). Using HOTS-based chemistry national exam questions to map the analytical abilities of senior high school students. *Journal of Science Learning*, *3*(3), 143–148. https://doi.org/10.17509/jsl.v3i3.22387

Herman, B. C., Newton, M. H., & Zeidler, D. L. (2021). Impact of place-based socioscientific issues instruction on students' contextualization of socioscientific orientations. *Science Education*, *105*(4), 585–627. https://doi.org/10.1002/sce.21618

Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2024). Teaching socioscientific issues: A systematic review. *Science and Education*, *34*(5), 3079–3122. https://doi.org/10.1007/s11191-024-00542-y

Horvat, S. A., Mihajloviæ, J., Ronèeviæ, T. N., & Rodiæ, D. D. (2021). Procedure for the assessment of cognitive complexity: development and implementation in the topic "hydrolysis of salts." *Macedonian Journal of Chemistry and Chemical Engineering*, *40*(1), 119–130. https://doi.org/10.20450/MJCCE.2021.2240

Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. (2017). Students' science process skill and analytical thinking ability in chemistry learning. *AIP Conference Proceedings*, *1868*(1), 30001. https://doi.org/10.1063/1.4995100

Jaenudin, R., Chotimah, U., Farida, & Syarifuddin. (2020). International Journal of Multicultural and Multireligious Understanding Student Development Zone/ : Higher Order Thinking Skills (HOTS) in Critical Thinking Orientation. *International Journal of Multicultural and Multireligious Understanding*, *7*(9), 11–19.

Karenina, A., Widoretno, S., & Prayitno, B. A. (2020). Effectiveness of problem solving-based module to improve analytical thinking. *Journal of Physics: Conference Series*, *1511*(1). https://doi.org/10.1088/1742-6596/1511/1/012093

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2020). Students' perceptions of socio-scientific issue-based learning and their appropriation of epistemic tools for systems thinking. *International Journal of Science Education*, *42*(8), 1339–1361. https://doi.org/10.1080/09500693.2020.1759843

Kurniawan, S. (2025). Transformation Education System and Challenges and Opportunities in the 21st Century. *Nuris Journal of Education and Islamic Studies*, *5*(2), 139–150. https://doi.org/10.52620/jeis.v5i2.121

Kusumaningrum, Y. D., Budiasih, E., & Suharti, S. (2021). Effect of integration of SETS (science-environment-technology-society) in 7E learning cycle on students' critical thinking skills. *AIP Conference Proceedings*, *2330*. https://doi.org/10.1063/5.0043357

Laliyo, L. A. R., La Kilo, A., Paputungan, M., Kunusa, W. R., Dama, L., & Panigoro, C. (2022). Rasch Modelling To Evaluate Reasoning Difficulties, Changes of Responses, and Item Misconception Pattern of Hydrolysis. *Journal of Baltic Science Education*, *21*(5), 817–835. https://doi.org/10.33225/jbse/22.21.817

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research*, *86*(3), 681–718. https://doi.org/10.3102/0034654315627366

Lowell, V. L., & Moore, R. L. (2020). Developing practical knowledge and skills online instructional design students through authentic learning and real-world activities. *TechTrends*, *64*(4), 581–590. https://doi.org/10.1007/s11528-020-00518-z

Madina, N. (2024). Factors influencing students' attitude towards science subjects in Secondary Schools: A case study of Secondary Schools in Kisseka Sub-County, Masaka District. *Iaa Journal of Education*, *10*(2), 13–26. https://doi.org/10.59298/iaaje/2024/102.1326.11

Malik, R. S. (2018). Educational Challenge in 21st Century and Sustainable Development. *Journal of Sustainable Development Education and Research*, *2*(1), 9–20.

Mardhiyah, R. H., Aldriani, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). *Pentingnya keterampilan belajar di abad 21 sebagai tuntutan dalam pengembangan sumber daya manusia* [The importance of learning skills in the 21st century as a requirement in human resource development]. *Lectura/ : Jurnal Pendidikan*, *12*(1), 29–40. https://doi.org/10.31849/lectura.v12i1.5813

Marfilinda, R., Zaturrahmi, & Suma Indrawati, E. (2019). Development and application of learning cycle model on science teaching and learning: A literature review. *Journal of Physics: Conference Series*, *1317*(1). https://doi.org/10.1088/1742-6596/1317/1/012207

Martin, R., Sexton, C., & Gerlovich, J. (2001). *Teaching Science for All Childern* (3th ed.). Person Education Company.

Mekonnen, Z. B., Yehualaw, D. D., Mengistie, S. M., & Mersha, B. S. (2024). The effect of 7E learning cycle enriched with computer animations on students' conceptual understanding and overcoming misconceptions. In *Journal of Pedagogical Research* (Vol. 8, Issue 2). https://doi.org/10.33902/JPR.202425017

Misbah, M., Dewantara, D., Hasan, S. M., & Annur, S. (2018). The development of student worksheet by using guided inquiry learning model to train student's scientific attitude. *Unnes Science Education Journal*, *7*(1), 19–26.

Musfiroh, M., Suwarma, I. R., & Efendi, R. (2024). Enhancing physics learning through the 7E learning cycle model: A systematic literature review. *Indonesian Journal of Science and Mathematics Education*, *7*(3), 531. https://doi.org/10.24042/ijsme.v7i3.24125

Mustafa, L. K., & Suyanta. (2019). Exploring students' integrated ability and creativity: Using 7e learning cycle model in chemistry learning. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012019

Muthma'Innah, M., Dahlan, J. A., & Suhendra, S. (2019). Ability of mathematical critical thinking - What about Learning Cycle 7E model? *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032129

Noreen, Z., Iqbal, M., & Hayat, K. (2024). Effect of the 7E learning cycle model on students' achievement in the subject of science at the elementary school level. *Qlantic Journal of Social Sciences*, *5*(2), 34–45. https://doi.org/10.55737/qjss.315497375

Nurlatifah, S., Tukiran, T., & Erman, E. (2018). The development of learning material using learning cycle 7E with socio-scientific issues context in rate of reaction to improve studentrs argumentation skills in senior high school. *Advances in Intelligent Systems Research (AISR)*, *157*(Miseic), 81–86. https://doi.org/10.2991/miseic-18.2018.20

Orosz, G., Németh, V., Kovács, L., Somogyi, Z., & Korom, E. (2022). Guided inquiry-based learning in secondary-school chemistry classes: A case study. *Chemistry Education Research and Practice*, *24*(1), 50–70. https://doi.org/10.1039/d2rp00110a

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Owens, D. C., & Sadler, T. D. (2024). Socio-scientific issues instruction for scientific literacy: 5E Framing to enhance teaching practice. *School Science and Mathematics*, *124*(3), 203 – 210. https://doi.org/10.1111/ssm.12626

Perdana, R., Yanfika, H., Sholehurrohman, R., & Bertiliya, W. A. (2024). Developing worksheet-based 7E learning cycle to foster elementary school students' critical and creative thinking skills. *Journal of Educational Management and Instruction (JEMIN)*, *4*(1), 196–212. https://doi.org/10.22515/jemin.v4i1.9659

Prastika, F. N. K., & Arianingrum, R. (2025). The socioscientific issues approach in chemistry education: A literature study and its implication. *Jurnal Pendidikan MIPA*, *15*(3), 723–731.

Prianti, T., Susanti VH, E., & Indriyanti, N. Y. (2020). Misconceptions of high school students in salt hydrolysis topic using a three-tier diagnostic test (TTDT). *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, *5*(1), 32. https://doi.org/10.20961/jkpk.v5i1.34502

Puspita, L., Budiman, H., & Thessalonica, M. A. (2018). *Pengaruh model learning cycle tipe 7E disertai teknik talking stick terhadap sikap ilmiah siswa pada materi protista* [The influence of the 7E type learning cycle model accompanied by the talking stick technique on students' scientific attitudes towards protist material]. *Biosfer: Jurnal Tadris Biologi*, *9*(2), 205–216. https://doi.org/10.24042/biosfer.v9i2.3966

Rahman, M. S., & Chavhan, D. R. (2022). 7E model: An effective instructional approach for teaching learning. *EPRA International Journal of Multidisciplinary Research (IJMR)*, *8*(1), 339–345. https://doi.org/10.36713/epra9431

Ramadani, A. S., Supardi, Z. A. I., Tukiran, & Hariyono, E. (2021). Profile of analytical thinking skills through inquiry-based learning in science subjects. *Studies in Learning and Teaching*, *2*(3), 45–60. https://doi.org/10.46627/silet.v2i3.83

Rampean, B., Roheti, E., Septriwanto, J., & Lengkong, M. (2021). How can open inquiry enhancing students' scientific attitude through chemistry learning? *Proceedings of the 7th International Conference on Research, Implemen tation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, *528*(Icriems, 2020), 238–245. https://doi.org/10.2991/assehr.k.210305.035

Ren, X., Zu, Y., & Ud Din, S. Z. (2025). Optimizing Classroom Ecology through Learning Analytics to Improve Teaching and Student Engagement. *Interciencia*, *408*(6), 2–27. https://doi.org/10.59671/anvbo

Rohaeti, E., Prodjosantoso, A. K., & Irwanto. (2020). Research-oriented collaborative inquiry learning model: Improving students' scientific attitudes in general chemistry.

Journal of Baltic Science Education, *19*(1), 108–120. https://doi.org/10.33225/jbse/20.19.108

Rosidin, A., Sudirman, S., Mufti, M. I., Pramono, S. A., Susanty, L., Dudin, A., Ernawati, & Arifin, A. (2025). Exploring Educational Policy Innovations and Curriculum Development in Indonesian Higher Education: A Systematic Review. *Journal of Education Culture and Society*, *16*(2), 943–958. https://doi.org/10.15503/jecs2025.3.943.958

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5), 513–536. https://doi.org/10.1002/tea.20009

Sadler, T. D. (2009). Situated learning in science education: Socio-scientific issues as contexts for practice. In *Studies in Science Education* (Vol. 45, Issue 1). https://doi.org/10.1080/03057260802681839

Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching*, *42*(1), 112–138. https://doi.org/10.1002/tea.20042

Sarwanto, S., Fajari, L. E. W., & Chumdari, C. (2021). Critical thinking skills and their impacts on elementary school students. *Malaysian Journal of Learning and Instruction*, *18*(2), 161–188.

Shidiq, A. S., Yamtinah, S., & Masykuri, M. (2019). Identifying and addressing students' learning difficulties in hydrolysis using testlet instrument. *AIP Conference Proceedings*, *2194*(December). https://doi.org/10.1063/1.5139849

Solbes, J., Torres, N., & Traver, M. (2018). Use of socio-scientific issues in order to improve critical thinking competences. *Asia-Pacific Forum on Science Learning and Teaching*, *19*(1).

Suardana, I. N., Redhana, I. W., Sudiatmika, A. A. I. A. R., & Selamat, I. N. (2018). Students' critical thinking skills in chemistry learning using local culture-based 7E learning cycle model. *International Journal of Instruction*, *11*(2), 399–412. https://doi.org/10.12973/iji.2018.11227a

Sugrah, N., Suyanta, & Wiyarsi, A. (2023). Promoting students' critical thinking and scientific attitudes through socio-scientific issues-based flipped classroom. *Lumat*, *11*(1), 140–165. https://doi.org/10.31129/LUMAT.11.1.1856

Supardi, R., Istiyono, E., & Setialaksana, W. (2019). Developing scientific attitudes instrument of students in chemistry. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012025

Suryawati, E., & Osman, K. (2018). Contextual learning: Innovative approach towards the development of students' scientific attitude and natural science performance. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 61–76. https://doi.org/10.12973/ejmste/79329

Tsai, C.-Y. (2018). The effect of online argumentation of socio-scientific issues on students' scientific competencies and sustainability attitudes. *Computers & Education*, *116*, 14–27. https://doi.org/https://doi.org/10.1016/j.compedu.2017.08.009

Üce, M., & Ceyhan, Ý. (2019). Misconception in Chemistry Education and Practices to Eliminate Them: Literature Analysis. *Journal of Education and Training Studies*, *7*(3), 202. https://doi.org/10.11114/jets.v7i3.3990

Udonsathian, T., & Worapun, W. (2024). Enhancing analytical thinking in grade 8 science education: Integrating 5E inquiry-based and 5W1H techniques. *International Journal of Advanced and Applied Sciences*, *11*(5), 62–69. https://doi.org/10.21833/ijaas.2024.05.007

Uyanýk, G. (2016). Effect of learning cycle approach-based science teaching on academic achievement, attitude, motivation, and retention. *Universal Journal of Educational Research*, *4*(5), 1223–1230. https://doi.org/10.13189/ujer.2016.040536

Wahyudiati, D. (2022). Critical thinking skills and scientific attitudes of pre-service chemistry teachers through the implementation of problem-based learning model. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 216–221. https://doi.org/10.29303/jppipa.v8i1.1278

Wen, C., Liu, C., Chang, H., & Chang, C. (2020). Computers & education students' guided inquiry with simulation and its relation to school science achievement and scientific literacy. *Computers & Education*, *149*(February), 103830. https://doi.org/10.1016/j.compedu.2020.103830

Whudian, A., Park, Y., & Atanga, R. A. (2023). The effect of applying the learning cycle learning model on students' learning outcomes of geography. *Indonesian Journal of Education Research (IJoER)*, *4*(4), 97–106. https://doi.org/10.37251/ijoer.v4i4.708

Wibowo, A., & Suyanta. (2019). Integrated thinking ability and activities on eleventh grader students through learning cycle 7E. *Journal of Physics: Conference Series*, *1156*(1). https://doi.org/10.1088/1742-6596/1156/1/012016

Wodaj, H., & Belay, S. (2021). Effects of 7E Instructional Model with Metacognitive Scaffolding on Students' Conceptual Understanding in Biology. *Journal of Education in Science, Environment and Health (JESEH)*, *7*(1), 26–43. https://doi.org/https://doi.org/10.21891/jeseh.770794

Yennita, Astriawati, F., Jumiarni, D. (2023). *Learning cycle 7E: efektivitasnya dalam meningkatkan high order thinking skills (HOTS) mahasiswa pada mata kuliah anatomi tumbuhan* [Learning cycle 7E: Its effectiveness in improving students' high order thinking skills (HOTS) in plant anatomy courses]. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, *7*(1), 124–132. https://doi.org/10.33369/diklabio.7.1.124-132

Zamakhsyari & Rahayu, S. (2020). Fostering ill-structured problem-solving skills of chemistry students using socioscientific issues as learning contexts. *AIP Conference Proceedings*, *2215*(April). https://doi.org/10.1063/5.0000533

Zeidler, D. L., Herman, B. C., & Sadler, T. D. (2019). New directions in socioscientific issues research. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1–9. https://doi.org/10.1186/s43031-019-0008-7

Zeidler, D. L., & Keefer, M. (2003). *The role of moral reasoning on socioscientific issues and discourse in science education*.