International Journal of Pedagogy and Teacher Education

Journal Homepage: jurnal.uns.ac.id/ijpte

The Effect of Investigation Through Cooperative Problem Solving (ITCPS) Learning Model on Students' Activeness, Analytical Thinking Skills, and Science Learning Outcomes

Lafi Rusdiana, Budi Utami, Daru Wahyuningsih
Department of Science Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

ARTICLE INFO

Article History
Received : February 21, 2025
1st Revision : March 16, 2026
Accepted : April 26, 2026
Available Online: April 30, 2026

Keywords:
ITCPS learning model; Students' Activity; Analytical Thinking Skills; Science Learning Outcomes; Science Education

***Corresponding Author**
Email address:
budiutami@staff.uns.ac.id

ABSTRACT

Students' low activeness, analytical thinking skills, and science learning outcomes remain key challenges in lower secondary science learning when instruction provides limited opportunities for investigation, collaboration, and problem solving. This study examined the effect of the Investigation Through Cooperative Problem Solving (ITCPS) learning model on these three outcomes. A quasi-experimental method with a pretest-posttest nonequivalent control group design was used. The participants were 60 eighth-grade students at a middle school in Surakarta, Indonesia, consisting of 30 in the experimental class and 30 in the control class. The experimental class was taught using ITCPS, while the control class used Discovery Learning. Data were collected using an activeness observation sheet, an analytical thinking essay test, and a multiple-choice science learning outcomes test, then analyzed using descriptive statistics, assumption tests, and MANOVA. Results showed significant effects on activeness, F(1, 58) = 12.158, p = .001, partial eta squared = .173; analytical thinking skills, F(1, 58) = 9.023, p = .004, partial eta squared = .135; and science learning outcomes, F(1, 58) = 9.415, p = .003, partial eta squared = .140. The multivariate test also showed a significant simultaneous effect, with partial eta squared = .271. These findings indicate that ITCPS supports students' active participation, analytical reasoning, and conceptual achievement in science learning.

How to cite: Rusdiana, L., Utami, B., & Wahyuningsih, D. (2026). The Effect of Investigation Through Cooperative Problem Solving (ITCPS) Learning Model on Students' Activeness, Analytical Thinking Skills, and Science Learning Outcomes. *International Journal of Pedagogy and Teacher Education,* 10(1), 102–116. https://doi.org/10.20961/ijpte.v10i1.99755

1. INTRODUCTION

Science learning in lower secondary education is increasingly expected to develop not only conceptual understanding but also students' capacity to participate actively, reason analytically, and solve problems collaboratively. These competencies are central to contemporary education because skills related to analysing data and information are projected to be among the most rapidly growing demands in the labour market between 2019 and 2030 (OECD, 2023). International assessment data also indicate that many students still struggle to apply scientific knowledge for reasoning and evidence-based decision-making. In Indonesia, only 34% of students reached Level 2 or higher in science in PISA 2022, far below the OECD average of 76% (OECD, 2023). This condition suggests that science classrooms need instructional models that can move students beyond passive reception of information toward active investigation, collaborative reasoning, and analytical problem solving.

Student activeness is a key condition for meaningful science learning because learning engagement includes behavioral, emotional, and cognitive participation in classroom activities (Fredricks et al., 2004). Active learning is not limited to physical involvement; it requires students to observe, question, discuss, explain, and reflect on ideas during learning activities. A large meta-analysis in STEM education showed that active learning improves examination performance and reduces failure rates compared with traditional lecturing (Freeman et al., 2014). Active-learning environments can also reduce achievement gaps when students are provided with structured opportunities to participate and process ideas collaboratively (Theobald et al., 2020). Therefore, students' activeness should be treated as an important learning outcome as well as a process that supports higher-order thinking and science achievement.

Analytical thinking is particularly important in science learning because students need to identify relationships among concepts, classify information, detect errors, draw generalizations, and specify relevant evidence when solving scientific problems. Analytical thinking is closely related to students' ability to interpret data, evaluate explanations, and use logical reasoning in unfamiliar contexts (Irwanto et al., 2017; Fitriyana et al., 2019). Previous studies also indicate that students' analytical thinking may remain underdeveloped when classroom questions are dominated by lower cognitive levels and when learning activities provide limited opportunities for inquiry and argumentation (Amiza & Aloysius, 2024; Ilma et al., 2017). Science instruction therefore needs to be designed to train students to analyze phenomena rather than merely remember definitions or procedural steps. Preliminary observations and interviews with science teachers at a middle school in Surakarta showed that students were still not actively involved in science learning. Students tended to show limited enthusiasm, hesitated to express opinions or ask questions, and had difficulty connecting science concepts to daily-life phenomena. Preliminary test results also indicated low mastery of analytical thinking indicators, including adjustment, classification, analyzing errors, generalization, and specification. The preliminary concept mastery score was also relatively low, indicating that students' activeness, analytical thinking skills, and science learning outcomes were interrelated problems in the observed classroom context. Similar findings have been reported in previous studies showing that teacher-centered instruction often limits student participation, higher-order thinking, and learning outcomes (Sizi et al., 2021; Furqan et al., 2015; Alyusfitri et al., 2024).

Instructional models grounded in inquiry, collaboration, and problem solving offer a promising response to these problems. Problem-based learning encourages students to learn through facilitated problem solving, collaborative inquiry, self-directed learning, and reflection (Hmelo-Silver, 2004). Inquiry-based science teaching can improve learning when students are supported with adequate guidance rather than left to discover concepts without structure (Furtak et al., 2012; Lazonder & Harmsen, 2016). Guided learning is important because minimally guided discovery may not be sufficient for students who still need conceptual and procedural support (Mayer, 2004). Collaborative problem solving also has strong potential to promote students' higher-order thinking because it requires learners to negotiate ideas, justify reasoning, and construct shared solutions (Xu et al., 2023). The Investigation Through Cooperative Problem Solving (ITCPS) learning model is relevant to this need because it integrates cooperative learning and problem-solving activities into a structured inquiry sequence. The ITCPS model consists of identifying problems, formulating problems, investigating, explaining, and reflecting (Utami et al., 2019a; Utami et al., 2019b; Utami et al., 2023). Through these stages, students are expected to observe a problem, work collaboratively, conduct investigation, communicate findings, and reflect on the solution process. This structure aligns with constructivist and inquiry-based perspectives because students are guided to build understanding through interaction with problems, peers, evidence, and teacher facilitation. Therefore, ITCPS has theoretical potential to support students' activeness, analytical thinking skills, and science learning outcomes simultaneously.

Existing studies on ITCPS have reported its potential contribution to students' affective development, social interaction, and critical thinking in science or chemistry learning (Utami et al., 2023). Nevertheless, empirical evidence remains limited regarding whether ITCPS can simultaneously influence students' behavioral activeness, analytical thinking skills, and cognitive science learning outcomes in lower secondary science classrooms. This gap is important because analytical thinking is more specific than general critical thinking and requires students to perform measurable cognitive operations such as matching, classifying, analyzing errors, generalizing, and specifying. Previous ITCPS research has also not sufficiently positioned the model as an integrated intervention for both classroom participation and cognitive achievement in the topic of simple machines. This study offers novelty by examining the effect of the ITCPS learning model on three interrelated outcomes: students' activeness, analytical thinking skills, and science learning outcomes, within one quasi-experimental design involving eighth-grade students in a middle school science classroom. The study contributes to the literature by providing empirical evidence on how a structured cooperative problem-solving model can support both the process dimension of learning, represented by student activeness, and the cognitive dimension of learning, represented by analytical thinking and science achievement. Specifically, this study aims to determine the effect of the ITCPS learning model on (1) students' activeness, (2) students' analytical thinking skills, (3) students' science learning outcomes, and (4) the three outcomes simultaneously.

2. MATERIAL AND METHOD

Research Design

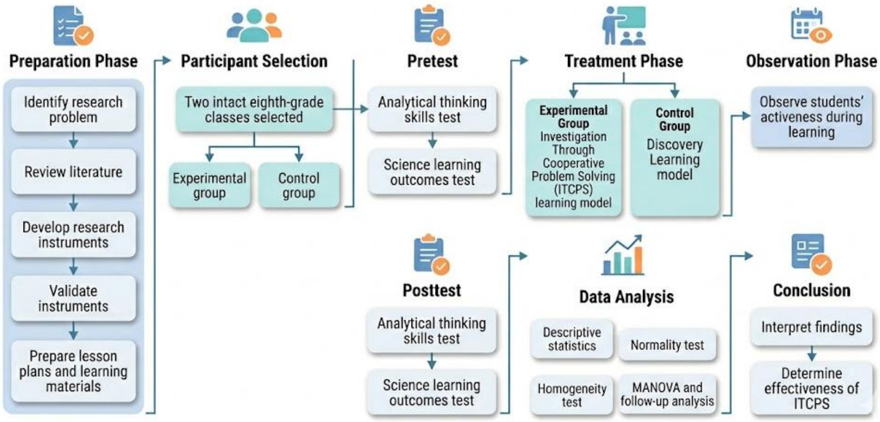

Figure 1. Research Flow of the Quasi-Experimental Study

This study employed a quasi-experimental method using a pretest-posttest nonequivalent control group design. This design was considered appropriate because the research was conducted in naturally existing classroom settings, where random assignment of individual students to different groups was not feasible. Two intact eighth-grade classes were therefore selected to participate in the study. One class was assigned as the experimental group and received instruction through the Investigation Through Cooperative Problem Solving (ITCPS) learning model, whereas the other class was assigned as the control group and received instruction through Discovery Learning. This design enabled the researcher to compare the effectiveness of the two learning models in improving students' activeness, analytical thinking skills, and science learning outcomes under authentic classroom conditions. Figure 1 presents the overall flow of the study, beginning from the preparation phase to the final data analysis and conclusion.

Figure 1 illustrates that the research procedure was organised into three major phases, namely the preparation phase, the implementation phase, and the final evaluation phase. The preparation phase included identifying the research problem, reviewing relevant literature, preparing lesson plans and learning materials, developing research instruments, and validating the instruments prior to use. The implementation phase began with the administration of a pretest in both groups to identify students' initial analytical thinking skills and science learning outcomes. Following the pretest, the experimental class was taught using the ITCPS learning model, while the control class was taught using Discovery Learning. During the learning process, students' activeness was observed systematically using an observation sheet. The final evaluation phase involved administering a posttest to both groups after the treatment had been completed. The posttest aimed to measure students' analytical thinking skills and science learning outcomes after instruction. The resulting data from the pretest, posttest, and classroom observation were then analysed statistically to determine the effectiveness of the ITCPS learning model compared with Discovery Learning.

Participants

The population of this study consisted of all eighth-grade students at a public junior secondary school in Surakarta, Indonesia. The school had eight eighth-grade classes. Prior to sample selection, students' previous science midterm scores were examined to assess the baseline equivalence of the population. The preliminary analysis showed that most classes had normally distributed science scores, and the homogeneity test indicated that the population variance was homogeneous, with Levene's statistic = 1.032 and p = .409. These results suggested that the eighth-grade classes were sufficiently comparable to be considered for inclusion in the study. The sample was selected at the class level because the students had already been organized into intact classes by the school, making individual random assignment impractical in the natural classroom setting. One eighth-grade class was assigned as the experimental group and another as the control group. Based on the final analytic dataset, the study involved 60 students, consisting of 30 students in the experimental class and 30 students in the control class. Both classes studied the same science topic, followed the same curriculum, and were taught within the same school context. This arrangement allowed the study to compare the effects of the two instructional models under relatively equivalent educational conditions.

Learning Topic and Intervention

The learning topic used in this study was simple machines. The topic included the definition of simple machines, types of levers, inclined planes, pulleys, mechanical advantage, and the application of simple machines in daily life. This topic was selected because it allows students to observe contextual phenomena, analyze visual representations, solve quantitative problems, and connect science concepts with everyday situations. The experimental class was taught using the ITCPS learning model. The model consisted of five syntaxes: identifying problems, formulating problems, investigating, explaining, and reflecting (Utami et al., 2023). The control class was taught using Discovery Learning. Both classes studied the same topic, followed the same curriculum objectives, and completed the same assessment instruments. Table 1 summarizes the treatment procedures in the experimental and control classes.

Table 1. Treatment procedures in the experimental and control classes

Stage	ITCPS class	Discovery Learning class
Orientation	Observed contextual problems on simple machines.	Observed learning materials on simple machines.
Problem formulation	Identified problems and formulated hypotheses.	Identified relevant information from materials.
Investigation	Conducted cooperative investigation, experiments, and problem solving.	Collected and processed information through guided discovery.
Explanation	Presented findings and responded to feedback.	Verified concepts through guided discussion.
Reflection	Reflected on solutions and clarified concepts.	Drew conclusions from the discovery process.
Main focus	Cooperative problem solving and investigation.	Concept discovery and verification.

Instruments

This study used three main instruments: an observation sheet for students’ activeness, an essay test for analytical thinking skills, and a multiple-choice test for cognitive science learning outcomes. The instruments were developed based on the indicators of each dependent variable. Table 2 presents the relationship among variables, instruments, indicators, number of items, and scoring procedures. The students’ activeness observation sheet was adapted from Wibowo (2016). The instrument consisted of five aspects: attention, cooperation and social relations, expressing ideas, problem solving, and discipline. Each aspect consisted of three observable indicators. Attention referred to students’ focus on teacher explanation, task completion, and information searching. Cooperation and social relations referred to students’ participation in group discussion, mutual assistance, and compromise in decision-making. Expressing ideas referred to students’ ability to share opinions, respond to peers, and ask clarification questions. Problem solving referred to students’ effort to find answers, analyze observation data, and connect data with learning materials. Discipline referred to students’ ability to follow learning rules, accept group arrangements, and complete tasks on time.

The analytical thinking skills test consisted of five essay questions based on Marzano and Kendall’s taxonomy (Marzano & Kendall, 2007). The five aspects were matching, classifying, analyzing errors, generalizing, and specifying. Matching measured students’ ability to identify similarities and differences. Classifying measured students’ ability to identify categories and explain relationships based on attributes. Analyzing errors measured students’ ability to identify misconceptions or incorrect applications of concepts. Generalizing measured students’ ability to draw conclusions from known concepts and principles. Specifying measured students’ ability to predict what might happen in a given situation.

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

The instruments were validated before being used in the main data collection. Content validity was examined through expert judgment involving two experts in science education and physics education. The validation process covered conceptual relevance, construct alignment, content representativeness, language clarity, and scoring clarity. The expert judgment results were analyzed using Gregory's content validity formula. The content validity coefficient was 1.00 for the students' activeness observation sheet, the analytical thinking skills test, and the cognitive science learning outcomes test, indicating that the instruments were considered highly relevant to the measured constructs and the science topic. Empirical validity and reliability were also examined for the analytical thinking skills test and the cognitive science learning outcomes test. The analytical thinking skills test consisted of five essay items representing matching, classifying, analyzing errors, generalizing, and specifying. The item-total correlation coefficients ranged from .570 to .779, and the reliability coefficient was Cronbach's alpha = .678. The cognitive science learning outcomes test consisted of 15 multiple-choice items. The item-total correlation coefficients ranged from .106 to .579, and the reliability coefficient was Cronbach's alpha = .612. These results indicate that the instruments had acceptable validity evidence for classroom-based research, although the internal consistency of the cognitive learning outcomes test was moderate. Items with lower item-total correlations were reviewed to ensure their alignment with the learning indicators and the simple machines content.

Table 2. Research variables, instruments, indicators, and scoring procedures

Variable	**Instrument**	**Indicators**	**Items**	**Scoring procedure**
Students' activeness	Observation sheet	Attention, cooperation and social relations, expressing ideas, problem solving, and discipline	5 aspects, 15 indicators	Each aspect was scored 1–3, then converted to a 0–100 scale.
Analytical thinking skills	Essay test	Matching, classifying, analyzing errors, generalizing, and specifying	5 essay items	Each item was scored 1–3 using an analytical rubric, then converted to a 0–100 scale.
Science learning outcomes	Multiple-choice test	Simple machines, levers, inclined planes, pulleys, mechanical advantage, and daily-life applications	15 items	Correct answer = 1; incorrect answer = 0; total score converted to a 0–100 scale.

Data Collections and Analysis

Data collection was conducted in three sequential stages: pretest, treatment implementation, and posttest. Prior to the intervention, both classes completed the analytical thinking skills test and the cognitive science learning outcomes test in order to identify their initial abilities and establish baseline comparability between groups. The intervention phase was then carried out according to the assigned instructional model, with the experimental class receiving instruction through the Investigation Through Cooperative Problem Solving (ITCPS) model, while the control class learned through the Discovery Learning model. During this phase, students' activeness was systematically observed using an observation sheet that covered five dimensions, namely attention, cooperation and social relations, expressing ideas, problem solving, and discipline. Following the completion of the intervention, both classes were administered a posttest based on the same indicators as those used in the pretest. Scores obtained from the observation sheet, essay test, and multiple-choice test were subsequently compiled and prepared for statistical analysis.

Data were analyzed using both descriptive and inferential statistics. Descriptive statistical analysis included the calculation of the mean, maximum score, minimum score, variance, and standard deviation to provide an overall picture of students' performance across the measured variables. Prior to hypothesis testing, several prerequisite tests were conducted to ensure that the data met the assumptions required for multivariate analysis, including the Shapiro–Wilk test for normality, Levene's test for homogeneity of variance, and Box's M test for homogeneity of covariance matrices. (Bathke et al., 2018; Shapiro & Wilk, 1965) Data were considered to satisfy these assumptions when the significance value exceeded .05. Hypothesis testing was then performed using Multivariate Analysis of Variance (MANOVA), as the study examined the effect of one independent variable,

DOI: https://doi.org/10.20961/ijpte.v10i1.99755

namely the learning model, on three dependent variables: students' activeness, analytical thinking skills, and science learning outcomes. Follow-up univariate tests were subsequently conducted to examine the effect of the learning model on each dependent variable separately. The level of statistical significance was set at .05. Partial eta squared was reported to indicate the magnitude of both the univariate and multivariate effects (Bathke et al., 2018; Shapiro & Wilk, 1965; Friendly & Sigal, 2020).

3. RESULTS

Students' Activeness

Table 3. Statistic Descriptive Test of Students' Activeness

Statistic	Experiment	Control
Average	71.03	63.6
Maximal	91	87
Minimal	44	40
Variance	142.03	149.90
Std. Deviation	11.91	12.24

Students' activeness was measured using an observation sheet during the learning process, and the descriptive results are presented in Table 3. The data show that the experimental class achieved a higher mean activeness score (71.03) than the control class (63.60), indicating that students who learned through the ITCPS model tended to participate more actively during instruction. The difference of 7.43 points suggests a meaningful descriptive advantage for the experimental group. The maximum score in the experimental class (91) was also higher than that in the control class (87), while the minimum score in the experimental class (44) exceeded that of the control class (40). This pattern indicates that the experimental class not only reached a higher overall level of activeness, but also showed better participation among lower-performing students. In addition, the standard deviations in the two groups were relatively similar (11.91 in the experimental class and 12.24 in the control class), suggesting that the spread of activeness scores was comparable across groups (Sizi et al., 2021). Taken together, these descriptive findings indicate that the ITCPS learning model was associated with higher student activeness than Discovery Learning, although the statistical significance of this difference is examined in the subsequent inferential analysis (Sizi et al., 2021; Furqan et al., 2015).

Analytical Thinking Skills

Table 4. Statistic Descriptive Test of Students' Analytical Thinking Skills

Statistic	Experiment		Control	
	Pretest	Posttest	Pretest	Posttest
Average	56.60	70.23	50.43	63.73
Maximal	80	87	80	87
Minimal	33	47	13	40
Variance	190.11	132.66	417.56	178.89
Std. Deviation	13.78	11.51	20.43	13.37

Data on students' analytical thinking skills were obtained from the pretest and posttest, as presented in Table 4. The descriptive results indicate that both groups showed improvement after the intervention. The experimental class increased from a mean pretest score of 56.60 to a mean posttest score of 70.23, representing a gain of 13.63 points. The control class also improved, from 50.43 to 63.73, with a gain of 13.30 points. These results suggest that analytical thinking skills developed in both groups over the course of the study (Lazonder & Harmsen, 2016; Fitriyana et al., 2019). The experimental class, however, maintained a higher average score at both measurement points and achieved a higher final posttest mean than the control class. The maximum score in both groups increased from 80 at pretest to 87 at posttest, indicating that students in each class were able to reach a similarly high upper level of performance after instruction. The minimum score also increased in both groups, from 33 to 47 in the experimental class and from 13 to 40 in the control class, suggesting that lower-

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

performing students showed progress in both learning conditions. In addition, the standard deviation decreased from 13.78 to 11.51 in the experimental class and from 20.43 to 13.37 in the control class, indicating that students' scores became less dispersed after instruction (Achdiyat & Lestari, 2016). Taken together, these descriptive findings show that both instructional models were associated with improvement in analytical thinking skills, while the experimental class demonstrated a higher overall level of performance. The statistical significance of this difference is examined in the subsequent inferential analysis (Ismayanti et al., 2020; Lazonder & Harmsen, 2016; Fitriyana et al., 2019).

Cognitive Learning Outcomes

Table 5. Statistic Descriptive Test of Students' Cognitive Learning Outcome

Statistic	**Experiment**		**Control**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Average	58	72.2	55.56	63.2
Maximal	87	93	87	80
Minimal	33	47	20	33
Variance	163.44	119.82	262.32	134.47
Std. Deviation	12.78	10.94	16.19	11.59

Data on cognitive learning outcomes were collected through pretest and posttest scores obtained from a 15-item multiple-choice test, and the descriptive results are presented in Table 5. The data indicate that both groups experienced improvement after the learning intervention, but the magnitude of improvement was greater in the experimental class. The experimental class increased from a mean pretest score of 58.00 to a mean posttest score of 72.20, representing a gain of 14.20 points. The control class also improved, but only from 55.56 to 63.20, with a gain of 7.64 points. These results suggest that both learning models contributed to students' cognitive development, although the ITCPS model was associated with a stronger increase in science learning outcomes. The maximum score in the experimental class rose from 87 to 93, whereas in the control class the maximum score decreased from 87 to 80, indicating that the experimental class not only improved on average but also reached a higher upper level of achievement after instruction. The minimum score also increased in both groups, from 33 to 47 in the experimental class and from 20 to 33 in the control class, showing that lower-performing students in both classes made progress. Moreover, the standard deviation decreased from 12.78 to 10.94 in the experimental class and from 16.19 to 11.59 in the control class, indicating that students' posttest scores became less dispersed than their pretest scores (Aen & Kuswendi, 2020; Lutfirohmatika & Pertiwi, 2021). Taken together, these descriptive findings show that the experimental class achieved higher final performance and greater score improvement than the control class, suggesting that the ITCPS learning model was more effective in supporting students' cognitive science learning outcomes. The statistical significance of this difference is examined in the subsequent inferential analysis (Aen & Kuswendi, 2020).

Results of Prerequisite Test and Hypothesis Tests

Prerequisite tests were conducted before hypothesis testing to ensure that the data met the assumptions required for MANOVA. Normality was examined using the Shapiro–Wilk test, with a significance value greater than .05 indicating that the data were normally distributed. The results presented in Table 6 show that all significance values for students' activeness, analytical thinking skills, and learning outcomes in both the experimental and control classes exceeded .05. In the experimental class, the significance values were .063 for activeness, .116 for analytical thinking skills, and .257 for learning outcomes. In the control class, the corresponding values were .427, .052, and .093. These findings indicate that the distributions of all dependent variables were normal in both groups. The assumption of normality was therefore satisfied, meaning that the data were appropriate for subsequent multivariate analysis (Shapiro & Wilk, 1965).

Homogeneity was then examined using Box's M test to determine whether the covariance matrices of the dependent variables were equal across groups. The results are shown in Table 7. The analysis produced a Box's M value of 11.503, with F = 1.809, df1 = 6, df2 = 24373.132, and p = .093. Since the significance value was greater than .05, the covariance matrices were considered homogeneous. These results indicate that the data

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

met the homogeneity assumption required for MANOVA. Taken together, the prerequisite tests confirmed that the data were both normally distributed and homogeneous, so the dataset was suitable for hypothesis testing using multivariate analysis (Friendly & Sigal, 2020).

Table 6. Normality Test

Sig Shapiro-Wilk				
Class	Activeness	Analytical Thinking Skills	Learning Outcomes	Decision
Experiment	.063	.116	.257	Normally distributed
Control	.427	.052	.093	

Table 7. Results of Box's M Test

Box's M	**11.503**
F	1.809
df1	6
df2	24373.132
Sig	.093

Table 8. The Results of Hypothesis Testing for Hypothesis

Source	**Dependent Variable**	**F**	**Sig**	**Partial Eta Squared**
Class	Activeness	12.158	.001	.173
	Analytical Thinking Skills	9.023	.004	.135
	Learning Outcomes	9.415	.003	.140

Table 9. Hypothesis Test 4

Effect	**Sig**	**Partial Eta Squared**
Pillai's Trace	.000	.271
Wilks' Lambda	.000	.271
Hotelling's Trace	.000	.271
Roy's Largest Root	.000	.271

Univariate hypothesis testing for the first three hypotheses is presented in Table 8. The results show that the learning model had a significant effect on each dependent variable separately. Students' activeness yielded F(1, 58) = 12.158, p = .001, with partial eta squared = .173, indicating that the ITCPS learning model had a statistically significant and relatively strong effect on students' activeness. Analytical thinking skills yielded F(1, 58) = 9.023, p = .004, with partial eta squared = .135, showing that the learning model also significantly affected students' analytical thinking skills. Science learning outcomes yielded F(1, 58) = 9.415, p = .003, with partial eta squared = .140, indicating a significant effect of the ITCPS model on students' cognitive science achievement. Among the three outcomes, the strongest effect was found for students' activeness, followed by science learning outcomes and analytical thinking skills. These findings suggest that the ITCPS learning model was effective not only in increasing students' classroom participation, but also in improving their higher-order thinking and cognitive achievement.

Multivariate testing was then conducted to examine the simultaneous effect of the ITCPS learning model on students' activeness, analytical thinking skills, and science learning outcomes. The results are presented in Table 9. All multivariate criteria, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, showed the same significance pattern, with $p < .001$ and partial eta squared = .271. These results indicate that the learning model had a significant simultaneous effect on the three dependent variables. The partial eta squared value of .271 further suggests that 27.1% of the multivariate variance in students' activeness, analytical

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

thinking skills, and learning outcomes can be explained by the difference in learning model. This finding means that the fourth hypothesis was accepted. The ITCPS learning model therefore had a meaningful and statistically significant overall effect on students' participation, analytical reasoning, and science achievement when the three outcomes were considered together (Bathke et al., 2018).

4. DISCUSSION

Students' Activeness in ITCPS-Based Learning

Results in Table 8 showed that the ITCPS learning model had a significant effect on students' activeness, with F(1, 58) = 12.158, p = .001, and partial eta squared = .173. Descriptive statistics in Table 3 further support this result, showing that the experimental class achieved a higher mean activeness score (71.03) than the control class (63.60). The difference of 7.43 points indicates that students who learned through ITCPS were more actively involved in classroom activities than those who learned through Discovery Learning. The maximum score in the experimental class was also slightly higher (91) than in the control class (87), while the minimum score in the experimental class (44) exceeded that of the control class (40), suggesting that the ITCPS model not only promoted higher overall participation but also supported better engagement among lower-scoring students. The standard deviations of the two groups were relatively similar (11.91 in the experimental class and 12.24 in the control class), indicating that the spread of activeness scores was comparable across groups. Such a pattern suggests that the observed difference was not caused by unusual score dispersion, but reflected a more consistent tendency for students in the ITCPS class to participate more actively during learning. Active participation is essential for effective learning because students need to be engaged cognitively, socially, and behaviorally during classroom interaction. Taken together, the descriptive and inferential findings indicate that the ITCPS learning model was effective in strengthening students' activeness during science learning.

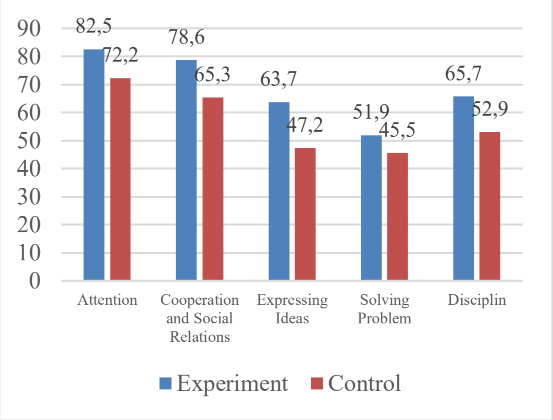

Figure 2. Learning Implementation in Cycle I and Cycle II

Figure 2 presents the distribution of students' activeness across the five observed aspects. Scores in the experimental class were consistently higher than those in the control class for all aspects, namely attention (82.5 vs. 72.2), cooperation and social relations (78.6 vs. 65.3), expressing ideas (63.7 vs. 47.2), solving problems (51.9 vs. 45.5), and discipline (65.7 vs. 52.9). Highest scores were found in the attention aspect, suggesting that ITCPS was particularly effective in directing students' focus during learning. Lower scores in the problem-solving aspect in both groups indicate that this dimension remained more difficult to develop, although the experimental class still showed a clear advantage. These findings suggest that ITCPS supported broader classroom participation rather than improving only one dimension of activeness. Each stage of the ITCPS model provides a plausible explanation for this pattern. Problem identification encouraged students to observe contextual representations of simple machines and analyze the information provided in the worksheet. Visual representations such as carts, bucket wells, and stairs likely helped students connect the problem situation with the science concepts being discussed, thereby increasing their attention and engagement (Prince, 2004). Observation activities are also fundamental in scientific inquiry because they allow students to collect evidence, test initial ideas, and construct

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

conclusions (Achdiyat & Lestari, 2016). Problem formulation then guided students to discuss the observed situation and propose hypotheses. This stage may have stimulated curiosity and encouraged students to ask questions, express tentative explanations, and become more involved in the learning process (Yam & Taufik, 2021; Ismayanti et al., 2020).

Investigation and explanation stages appear to be especially relevant for the higher scores in cooperation, social relations, and expressing ideas. Investigation required students to work collaboratively, conduct experiments, discuss evidence, and solve problems together. Opportunities to discuss, express opinions, and interpret findings are known to strengthen students' classroom participation and interaction skills (Achdiyat & Lestari, 2016). Cooperative investigation also encourages students to build social responsibility within the group, which is closely related to the cooperation and social relations aspect. Explanation activities further trained students to present their findings, respond to peer feedback, and defend their reasoning, processes that can stimulate more active classroom involvement and meaningful participation. Reflection likely contributed to the discipline aspect because students were required to evaluate their work, draw conclusions, and complete learning tasks in an orderly manner. Reflection provides students with a comprehensive understanding of what has been learned and encourages them to take part in decision making rather than functioning only as passive listeners (Ismayanti et al., 2020). Taken together, the evidence from Table 3, Table 8, and Figure 2 indicates that the ITCPS learning model was effective in increasing students' activeness across multiple aspects of classroom participation, especially attention and cooperation, while problem-solving activeness still required stronger support.

Effect of ITCPS on Students' Analytical Thinking Skills

Results in Table 8 showed that the ITCPS learning model had a significant effect on students' analytical thinking skills, with F(1, 58) = 9.023, p = .004, and partial eta squared = .135. Descriptive statistics in Table 4 also support this result, showing that the experimental class improved from a mean pretest score of 56.60 to a mean posttest score of 70.23, whereas the control class improved from 50.43 to 63.73. Both groups showed progress after instruction, but the experimental class achieved a higher final mean score than the control class. These findings indicate that learning through ITCPS was associated not only with general improvement in performance but also with stronger development of analytical thinking skills than Discovery Learning. This result is consistent with previous studies showing that analytical thinking develops more effectively when students are given opportunities to interpret data, connect concepts, evaluate errors, and construct evidence-based explanations rather than merely receive information passively (Irwanto et al., 2017; Fitriyana et al., 2019; Amiza & Aloysius, 2024).

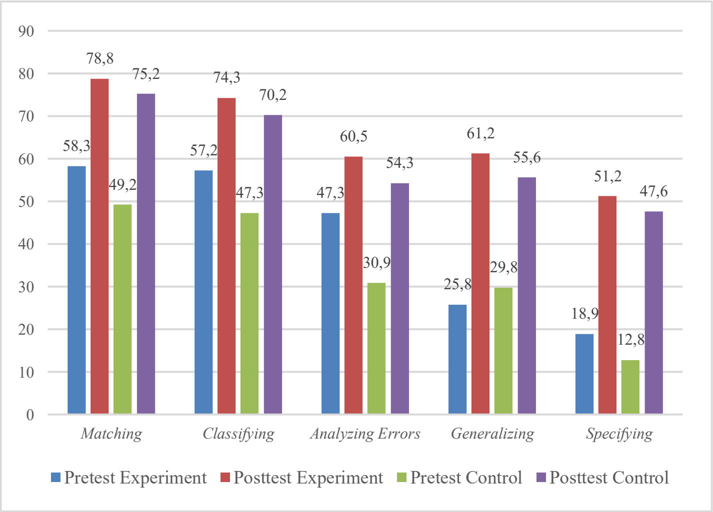

Figure 3. N-Gain Scores in Cycle I and Cycle II

A more detailed pattern can be seen in Figure 3, which shows that the experimental class obtained higher posttest scores on all aspects of analytical thinking, namely matching (78.8 vs. 75.2), classifying (74.3 vs. 70.2), analyzing errors (60.5 vs. 54.3), generalizing (61.2 vs. 55.6), and specifying (51.2 vs. 47.6). The highest posttest score in the experimental class appeared in the matching aspect, whereas the lowest remained in specifying. The relatively clear gaps in analyzing errors and generalizing suggest that ITCPS was particularly helpful in supporting students' ability to identify conceptual inaccuracies and draw broader conclusions from observed evidence. This pattern is in line with studies on inquiry-based and problem-solving-oriented learning, which emphasize that observing, discussing evidence, testing assumptions, and revising understanding can strengthen students' analytical skills in more specific ways (Furtak et al., 2012; Lazonder & Harmsen, 2016; Xu et al., 2023). These findings also extend earlier studies by showing not only that collaborative inquiry supports higher-order thinking in general, but also which analytical aspects appeared to develop more strongly in the context of simple machines.

Integration between the ITCPS syntax and the demands of analytical thinking may explain why the experimental class demonstrated better performance. The stages of problem identification and problem formulation gave students opportunities to recognize problem characteristics, distinguish examples, and classify concepts, making these stages particularly relevant to the matching and classifying aspects (Pedaste et al., 2015; Fakhrurrazi et al., 2019). The investigation stage encouraged students to collect and process experimental data, compare results, and check for possible inaccuracies, thereby contributing to the analyzing errors aspect. The explaining and reflection stages then provided students with opportunities to construct explanations, respond to peers' arguments, and draw conclusions, which are closely related to generalizing and specifying (Martiwi & Pertiwi, 2023). The implication of these findings is that science instruction should not focus only on concept discovery, but should also integrate structured cooperative problem solving so that students can gradually practise analyzing, checking errors, and forming generalizations. In this sense, ITCPS can be positioned not only as a model for increasing students' activeness, but also as a pedagogical strategy that supports the integration of classroom participation, analytical reasoning, and science concept mastery in a more comprehensive way.

Effect of ITCPS on Students' Science Learning Outcomes

Results in Table 8 showed that the ITCPS learning model had a significant effect on students' science learning outcomes, with F(1, 58) = 9.415, p = .003, and partial eta squared = .140. Descriptive statistics in Table 5 also support this result, showing that the experimental class improved from a mean pretest score of 58.00 to a mean posttest score of 72.20, whereas the control class improved from 55.56 to 63.20. Although both groups demonstrated progress after instruction, the experimental class achieved a higher final mean score and a larger score gain than the control class. These findings indicate that ITCPS was associated with stronger improvement in students' cognitive science learning outcomes than Discovery Learning. This result is consistent with previous studies showing that learning outcomes improve more effectively when students are actively involved in problem-solving, guided inquiry, and collaborative knowledge construction rather than passively receiving explanations (Hmelo-Silver, 2004; Furtak et al., 2012; Lazonder & Harmsen, 2016).

The stronger performance of the experimental class can be interpreted in relation to the structure of the ITCPS model itself. During the problem identification stage, students were exposed to contextual pictures and examples of simple machines, such as one-wheeled carts, bucket wells, scissors, nutcrackers, screws, and staircases, which helped them connect science concepts with familiar phenomena. Observation-based learning activities are known to increase students' attention, curiosity, and concentration, thereby supporting conceptual understanding (Aen & Kuswendi, 2020). The problem formulation stage then required students to analyze the observed problems, identify the working principles and functions of simple machines, and formulate hypotheses. Activities that require students to analyze and interpret problems have been shown to strengthen higher-order thinking and improve concept understanding (Sugianti et al., 2018). In this way, students were not only introduced to the topic content, but were also guided to build conceptual meaning from the outset of the learning process.

The investigation stage appears to have played a particularly important role in improving learning outcomes because students were required to carry out experiments, discuss findings, and process evidence collaboratively. Experimental activities provide direct experience that helps students remember and understand concepts more meaningfully (Utami et al., 2019b). Collaborative experimentation also enables students to

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

compare results, test initial assumptions, and refine understanding through interaction, which can strengthen cognitive achievement (Afdalia & Kasim, 2020). Furthermore, the explanation stage gave students opportunities to present the results of their investigations and respond to peer feedback, while the reflection stage helped them consolidate learning through shared conclusion making and teacher clarification. These activities are important because students who explain and reflect on their own reasoning tend to develop more systematic understanding of the concepts they have learned (Lutfirohmatika & Pertiwi, 2021). Taken together, the evidence from Table 5 and Table 8 suggests that ITCPS supported science learning outcomes not only by increasing participation, but also by integrating observation, analysis, experimentation, explanation, and reflection into a structured learning sequence. The pedagogical implication is that science learning should not rely solely on concept discovery, but should also incorporate guided cooperative problem solving so that students can build stronger conceptual understanding through active engagement with evidence and everyday phenomena.

ITCPS as an Integrated Model for Activeness, Analytical Thinking, and Learning Outcomes

Multivariate results in Table 9 showed that the ITCPS learning model had a significant simultaneous effect on students' activeness, analytical thinking skills, and cognitive learning outcomes, with p < .001 and partial eta squared = .271. This finding indicates that the contribution of ITCPS should not be interpreted only in relation to a single dependent variable, but rather as an integrated instructional effect across behavioral participation, analytical reasoning, and conceptual achievement. Such a pattern is consistent with the view that learning outcomes improve more strongly when students are engaged in structured interactive, constructive, and investigative activities rather than passive reception of information (Chi & Wylie, 2014; Minner et al., 2010; Xu et al., 2023). In the present study, the ITCPS syntax appears to provide that integration. The stages of problem identification and problem formulation encouraged students to observe, question, and classify phenomena, thereby supporting classroom activeness and early analytical processing. The investigation stage required students to work collaboratively, gather evidence, compare results, and evaluate possible errors, which likely strengthened both analytical thinking and conceptual understanding (Gillies, 2016). The explaining and reflection stages then provided opportunities for students to communicate findings, respond to feedback, and consolidate understanding, allowing participation, reasoning, and content mastery to develop together. This integrated pattern helps explain why the multivariate effect of ITCPS was stronger than Discovery Learning, which in this study tended to position the teacher more centrally in guiding and summarizing the learning process. The pedagogical implication is that science instruction should not treat activeness, analytical thinking, and learning outcomes as separate targets. Instead, they should be developed simultaneously through structured cooperative problem-solving activities that require students to engage with evidence, peers, and concepts in a sustained way. In this sense, ITCPS can be positioned as a pedagogical model that integrates participation, reasoning, and conceptual learning more comprehensively than instruction that emphasizes concept discovery without equally strong collaborative-investigative scaffolding (Xu et al., 2023; Gillies, 2016).

5. CONCLUSION

This study concludes that the Investigation Through Cooperative Problem Solving (ITCPS) learning model was more effective than Discovery Learning in improving eighth-grade students' activeness, analytical thinking skills, and cognitive science learning outcomes. The multivariate results demonstrated a significant simultaneous effect of the learning model on the three dependent variables, with $p < .001$ and partial eta squared = .271, indicating that ITCPS contributed meaningfully to students' classroom participation, analytical reasoning, and conceptual achievement as an integrated set of outcomes. Univariate results further confirmed significant effects on students' activeness, $F(1, 58) = 12.158$, $p = .001$, partial eta squared = .173; analytical thinking skills, $F(1, 58) = 9.023$, $p = .004$, partial eta squared = .135; and science learning outcomes, $F(1, 58) = 9.415$, $p = .003$, partial eta squared = .140. Descriptively, the experimental class also showed consistently higher mean scores than the control class across all three variables. These findings suggest that ITCPS is not only effective in promoting active classroom engagement, but also in supporting students' ability to analyze information, evaluate evidence, and understand science concepts more deeply through structured cooperative investigation and problem solving. Therefore, ITCPS can be recommended as a meaningful pedagogical alternative for lower secondary science instruction, particularly when teachers aim to develop student participation, higher-order thinking, and learning achievement simultaneously.

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.99755

6. REFERENCES

Achdiyat, M., & Lestari, K. D. (2016). *Prestasi belajar matematika ditinjau dari kepercayaan diri dan keaktifan siswa di kelas. Formatif: Jurnal Ilmiah Pendidikan MIPA, 6*(1), 50–61. https://doi.org/10.30998/formatif.v6i1.752

Aen, R., & Kuswendi, U. (2020). *Meningkatkan pemahaman konsep IPA siswa SD menggunakan media visual berupa media gambar dalam pembelajaran IPA. Journal of Elementary Education, 3*(3), 99–103. https://doi.org/10.22460/collase.v3i3.4273

Afdalia, R., & Kasim, A. (2021). Meningkatkan Hasil Belajar Siswa tentang Vertebrata Menggunakan Model Investigasi Kelompok Pada Kelas X IPA 3 MAN 1 PALU. *Journal of Biology Science and Education*, *8*(1), 577–582. https://doi.org/10.22487/jbse.v8i1.1163

Alyusfitri, R., Gistituati, N., Yerizon, Y., Fauzan, A., & Yarman, Y. (2024). The effectiveness and relationship of student responses toward learning outcomes using interactive multimedia-based e-modules in elementary school. International Electronic Journal of Elementary Education, 16(5), 573–584. Retrieved from https://iejee.com/index.php/IEJEE/article/view/2203

Amiza, R. F., & Aloysius, H. P. (2024). Penerapan model pembelajaran POGIL pada konsep asam basa terhadap kemampuan berpikir analitis siswa. Jurnal Riset Pembelajaran Kimia, 9(1), 13–26. https://doi.org/10.21831/jrpk.v9i1.19529

Bathke, A. C., Friedrich, S., Pauly, M., Konietschke, F., Staffen, W., Strobl, N., & Höller, Y. (2018). Testing mean differences among groups: Multivariate and repeated measures analysis with minimal assumptions. Multivariate Behavioral Research, 53(3), 348–359. https://doi.org/10.1080/00273171.2018.1446320

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. Educational Psychologist, 49(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Fakhrurrazi, F., Sajidan, S., & Karyanto, P. (2019). Analysis of students' analytical thinking skills in responding to the development of the industrial revolution 4.0. In *Proceedings of International Conference on Biology and Applied Science, 1*(1), 1–7. http://conferences.uin-malang.ac.id/index.php/icobas/article/view/894

Fitriyana, N., Marfuatun, M., & Priyambodo, E. (2019). The profile of student's analytical thinking skills on chemistry learning approach. Scientiae Educatia: Jurnal Pendidikan Sains, 8(2), 207–219. https://doi.org/10.24235/sc.educatia.v8i2.5272

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. Review of Educational Research, 74(1), 59–109. https://doi.org/10.3102/00346543074001059

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Friendly, M., & Sigal, M. (2020). Visualizing tests for equality of covariance matrices. The American Statistician, 74(2), 144–155. https://doi.org/10.1080/00031305.2018.1497537

Furqan, M., Karyanto, P., Rinanto, Y., & Salma, S. (2015). Penerapan e-module berbasis problem-based learning untuk meningkatkan kemampuan berpikir analitis dan menurunkan miskonsepsi siswa kelas X MIA 1 SMA Negeri Banyudono tahun pelajaran 2014/2015. Proceeding Biology Education Conference, 12(1), 410–414. https://doi.org/10.20961/bioedukasi-uns.v8i2.3868

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. Review of Educational Research, 82(3), 300–329. https://doi.org/10.3102/0034654312457206

Gillies, R. M. (2016). Cooperative learning: Review of research and practice. Australian Journal of Teacher Education, 41(3), 39–54. doi:10.14221/ajte.2016v41n3.3

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16, 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Ilma, R., Hamdani, A. S., & Lailiyah, S. (2017). Profil berpikir analitis masalah aljabar siswa ditinjau dari gaya kognitif visualizer dan verbalizer. JRPM (Jurnal Review Pembelajaran Matematika), 2(1), 1–14. https://doi.org/10.15642/jrpm.2017.2.1.1-14

Irwanto, Rohaeti, E., Widjajanti, E., & Suyanta. (2017). Students' science process skill and analytical thinking ability in chemistry learning. AIP Conference Proceedings, 1868, Article 030001. https://doi.org/10.1063/1.4995100

Ismayanti, I., Arsyad, M., & Marisda, D. H. (2020). *Penerapan strategi refleksi pada akhir pembelajaran untuk meningkatkan keterampilan berpikir kreatif peserta didik pada materi fluida*. *Karst: Jurnal Pendidikan Fisika dan Terapannya, 3*(1), 27–31. https://doi.org/10.46918/karst.v3i1.573

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

Lutfirohmatika, I., & Pertiwi, F. N. (2021). *Efektivitas model pembelajaran VAK (Visualization, Auditoy, and Kinestetics) dengan pendekatan literasi sains terhadap kemampuan presentasi peserta didik MTS kelas VII*. *Jurnal Tadris IPA Indonesia, 1*(3), 282–291. https://doi.org/10.21154/jtii.v1i3.386

Martiwi, E., & Pertiwi, F. N. (2023). Keterampilan berpikir analitis siswa melalui pembelajaran group investigation dengan pendekatan science literacy. Jurnal Tadris IPA Indonesia, 3(1). https://doi.org/10.21154/jtii.v3i1.871

Marzano, R. J., & Kendall, J. S. (2007). The new taxonomy of educational objectives. Corwin Press.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. American Psychologist, 59(1), 14–19. https://doi.org/10.1037/0003-066X.59.1.14

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002. Journal of Research in Science Teaching, 47(4), 474–496. https://doi.org/10.1002/tea.20347

OECD. (2023). PISA 2022 results (Volume I and II): Country notes: Indonesia. OECD Publishing. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/indonesia_c2e1ae0e-en.html

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review, 14, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Prince, M. (2004). Does active learning work? A review of the research. Journal of Engineering Education, 93(3), 223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). Biometrika, 52(3–4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Sizi, Y., Bare, Y., & Galis, R. (2021). Pengaruh model pembelajaran kooperatif tipe Talking Stick terhadap keaktifan dan hasil belajar kognitif peserta didik SMP kelas VIII. Spizaetus: Jurnal Biologi dan Pendidikan Biologi, 2(1), 39–46. https://doi.org/10.55241/spibio.v2i1.30

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., Chambwe, N., Cintrón, D. L., Cooper, J. D., Dunster, G., Grummer, J. A., Hennessey, K., Hsiao, J., Iranon, N., Jones, L., Jordt, H., Keller, M., Lacey, M. E., Littlefield, C. E., Lowe, A., Newman, S., Okolo, V., Olroyd, S., Peecook, B. R., Pickett, S. B., Slager, D. L., Caviedes-Solis, I. W., Stanchak, K. E., Sundaravardan, V., Valdebenito, C., Williams, C. R., Zinsli, K., & Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. Proceedings of the National Academy of Sciences, 117(12), 6476–6483. https://doi.org/10.1073/pnas.1916903117

Utami, B., Saputro, S., Ashadi, Masykuri, M., & Widoretno, S. (2019a). Performance assessment to assess students' interpretation in chemistry learning. AIP Conference Proceedings, 2194, Article 020109. https://doi.org/10.1063/1.5139867

Utami, B., Probosari, R. M, Saputro, S., Ashadi, & Masykuri, M. (2019b). Empowering critical thinking skills with problem solving in higher education. *Journal of Physics: Conference Series, 1280*(3), Article 032047. https://doi.org/10.1088/1742-6596/1280/3/032047.

Utami, B., Probosari, R.M., Saputro, S., Ashadi, & Masykuri, M. (2023). The effect of problem-solving and cooperative learning models on students' affective aspects and social interactions in learning chemical equilibrium. AIP Conference Proceedings, 2751, Article 050002. https://doi.org/10.1063/5.0143124

Wibowo, N. (2016). Upaya peningkatan keaktifan siswa melalui pembelajaran berdasarkan gaya belajar di SMK Negeri 1 Saptosari. Elinvo (Electronics, Informatics, and Vocational Education), 1(2), 128–139. https://doi.org/10.21831/elinvo.v1i2.10621

Xu, E., Wang, W., & Wang, Q. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. Humanities and Social Sciences Communications, 10, Article 16. https://doi.org/10.1057/s41599-023-01508-1

Yam, J. H., & Taufik, R. (2021). *Hipotesis penelitian kuantitatif*. *Perspektif: Jurnal Ilmu Administrasi, 3*(2), 96–102. https://doi.org/10.33592/perspektif.v3i2.1540