Vol 42, No 2 (2025): October 2025

Jurnal Penelitian Pendidikan

https://journal.unnes.ac.id/journals/JPP

Enhancing High School Students' Critical Thinking and Collaboration Skills on the Topic of Viruses Through the Service-Learning Model

Ahmad Naharuddin Ramadhan[1], Galuh Ajeng Antasari[2], Fitarahmawati[3], Muhammad Khoirul Antony[4], Sendy Putra Pradana[5]

[1,3]Universitas Negeri Semarang, Indonesia
[2]BOPKRI 2 Senior High School, Indonesia
[3]Universitas Sriwijaya, Indonesia
[4]Universitas Pattimura, Indonesia

Corresponding author: ahmadnr@mail.unnes.ac.id

Abstract

Strengthening critical thinking and collaboration skills has become an urgent need in 21st-century education; however, these skills remain relatively low among students. In fact, both are essential for navigating complex information, solving real-world problems, and working effectively in diverse teams. This study aims to examine the effectiveness of the service-learning model in enhancing the critical thinking and collaboration skills of tenth-grade students, as well as to investigate the correlation between these two skills in the context of a virus-related biology topic. A quasi-experimental design with a non-equivalent pretest-posttest control group was employed. The sample consisted of two classes (30 students each), selected using cluster sampling. Critical thinking skills were assessed through tests, while collaboration skills were measured using observation sheets. Data were analyzed using independent sample t-tests and Pearson correlation. The results showed that the service-learning model was effective in improving both critical thinking and collaboration skills, and there was a significant positive correlation between the two. The novelty of this study lies in the integration of the service-learning model into biology instruction on the topic of viruses, aiming to foster 21st-century skills through meaningful, experience-based learning approaches.

Keywords: Biology, Collaboration, Critical Thinking, Service Learning, Virus

INTRODUCTION

The importance of developing 21st-century skills, particularly critical thinking and collaboration, is widely recognized in modern education. As outlined by the Partnership for 21st Century Skills (P21), critical thinking is a core competency essential for navigating an era shaped by rapid technological change. Human-centered cognitive abilities that cannot be automated, such as critical thinking, are increasingly valued in education and the workforce (Kumar, 2023). In today's information-rich society—exacerbated by the proliferation of social media and artificial intelligence—critical thinking empowers individuals to discern truth, evaluate sources, and avoid misinformation (Machete & Turpin, 2020). Within the learning context, it supports independent problem-solving (Snyder & Snyder, 2008), exploration beyond teacher guidance (Nafisa et al., 2021), and deep understanding of subject matter (Cindiati et al., 2021).

In parallel, collaboration is another essential skill emphasized in 21st-century frameworks (Astiswijaya et al., 2023). It involves constructive teamwork, mutual respect, shared responsibility, and the ability to negotiate differing perspectives (Anggrella et al., 2024). Collaboration not only enhances academic outcomes but also contributes to students' communication abilities and socio-emotional development (Mahoney & Harris-Reeves, 2019; Huang & Lajoie, 2023). These competencies are critical for future professional environments that demand cross-functional teamwork (Saputri & Aminatun, 2020).

However, several studies have indicated that students' critical thinking and collaboration skills remain underdeveloped in many countries, including Indonesia (Zikrullah & Azhari, 2024; Firman et al., 2023). The 2021 TIMSS results ranked Indonesia 44th out of 49 countries, reflecting a low performance in higher-order thinking tasks (Oktaviani et al., 2023). National surveys and empirical findings also highlight limited

collaboration skills among Indonesian students (BPS, 2019; Latif et al., 2023).

Addressing these skill gaps requires more than conventional teaching methods. Effective learning models should foster active, contextual, and meaningful learning experiences that engage both cognitive and social domains (Dettmer, 2006; Dirgatama et al., 2016). One such model is service-learning, which integrates academic instruction with community service. It promotes the application of classroom knowledge to real-world issues, encouraging students to think critically and collaborate in solving authentic problems (Setyowati & Permata, 2018; Choi et al., 2023).

While service-learning has been widely applied in the social sciences and health education, its integration in natural sciences—particularly biology—remains limited (Nusanti, 2014; Bernot et al., 2017). Notably, there is a lack of studies focusing on service-learning within virology instruction at the senior high school level, especially in the Indonesian context. This gap is significant, given the high relevance of viral diseases in public health and the potential to contextualize learning through community-based projects (Ariizumi, 2025).

Therefore, this study aims to examine the effectiveness of implementing a service-learning model in biology instruction on the topic of viruses at the senior high school level. The focus is on enhancing: (1) students' critical thinking skills (cognitive aspect), (2) students' collaboration skills (social aspect), and (3) the relationship between these two competencies. By addressing an underexplored area in science education, the study seeks to contribute novel insights into experience-based instructional strategies that develop essential 21st-century skills through biologically relevant service-learning initiatives.

METHOD

This study employed a quantitative approach using a quasi-experimental method, specifically a non-equivalent control group design. The intervention was implemented during the even semester in April at a private senior high school in Yogyakarta City. The school was chosen due to its alignment with the goals of service-learning and its history of community service involvement, although such activities had not been integrated into formal instruction. The study was completed in June 2025.

Following Capili's (2021) framework, the population was divided into a target population—senior high school students who shared relevant characteristics—and an accessible population, namely all tenth-grade students at the selected school.

Two intact classes were involved: the experimental group received instruction using the service-learning model, while the control group received traditional instruction. The possibility of treatment contamination was minimized by using different teachers for each group and scheduling learning sessions on different days. Nevertheless, the risk of school-based diffusion is acknowledged as a limitation.

Data were collected using two instruments: a critical thinking test and an observation rubric for collaboration skills. The critical thinking test was developed based on Paul and Elder's (2008: 56) framework, assessing the ability to: (1) identify and define problems, (2) evaluate available evidence, (3) agree or disagree with assumptions, and (4) draw valid conclusions. One example of a critical thinking item used in the test is:

> "*In Puding Besar Village, many chickens died from the H5N1 virus. These chickens were buried after being burned. Later, chickens in the nearby Nibung Village also contracted the same disease. The poultry farmers in Puding Besar claim that their chickens could not have transmitted the virus. Do you agree? Justify your answer based on how viruses like H5N1 spread.*"

The collaboration rubric was adapted from Hermawan et al. (2017) and ReadWriteThink (2005), and assesses five components: (1) contribution, (2) time management, (3) problem solving, (4) working with others, and (5) inquiry techniques. Each component was rated on a 4-point scale. For instance, in the "Contribution" component, a student receives a score of 4 if they consistently contribute ideas and lead discussions, and a score of 1 if they do not participate.

Content and construct validity were ensured through expert reviews. Additionally, empirical validity was confirmed via item sensitivity analysis, using the formula:

$$S = \frac{\sum_1^n S_A - \sum_1^n S_B}{N(Max_{score} - Min_{score})}$$

Where ΣS_A is the total score of all students for one item after learning, ΣS_B is the total score of all students for one item after learning, Max_{score} is the maximum score for that item, Min_{score} is the minimum score for that item, and N is the number of students working on that item at the pretest and post-test. All

items yielded sensitivity indices between 0.75 and 0.78, exceeding the minimum threshold (0.75), indicating good sensitivity in differentiating student achievement (Gronlund, 1998).

Instrument reliability was assessed using the Subkoviak (1988) method. The |z| value and reliability coefficient (r) were calculated, followed by estimates of P_o (coefficient of agreement) and Kappa (K) using Subkoviak's (1985) tables. The Kappa coefficient was calculated by using the estimated method by first calculating the *z-score* ($|z|$) using the following formula:

$$|z| = \frac{(c - 0.5 - M)}{S}$$

where *c* is the cut-off score of the test, *M* is the average score of the test takers, and *S* is the standard deviation. Subsequently, the reliability coefficient (r) was determined by applying the following formula:

$$r = \frac{k}{k-1}\left[1 - \frac{\sum S_I^2}{S_T^2}\right]$$

where k is the number of items, ΣS_I^2 is the total number of item score variants, and S_T^2 is the total variant. Given the value of |z| and r, the magnitude of the Kappa coefficient (K) and the approval coefficient (P_o) can be calculated from the estimated table created by Subkoviak (1985). The summary is presented below (**Table 1**):

Table 1. Empirical validity calculation of the research instruments

Coefficients	Value
|z|	1.409
r	1.068
P_o	0.95
K	0.64

These results indicate the instrument is highly reliable, meeting the criteria of $P_o \geq 0.86$ and $K \geq 0.60$.

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics (mean, SD, max, min) were used to summarize students' critical thinking and collaboration scores. Inferential statistics included: independent sample t-tests for both pretest and posttest to assess initial equivalence and treatment effects, and also Pearson product-moment correlation to examine the relationship between critical thinking and collaboration skills.

Table 2. Interpretation of Effect Size Values according to Cohen (1988)

d	Interpretation
0.2	Small
0.5	Medium
0.8	Large
≥ 1.0	Ver Large

Additionally, effect size (Cohen's d) was calculated to determine the practical significance of any observed differences. The results of the effect size calculation using Cohen's d formula are interpreted according to the information in **Table 2** above.

RESULT AND DISCUSSION

Students' Critical Thinking Skills

The descriptive statistics of students' critical thinking pretest scores are presented in **Table 3**. Both the control and experimental groups showed nearly identical mean scores (13.86 and 13.83, respectively), indicating equivalent baseline abilities prior to the intervention.

Table 3. Descriptive statistics of critical thinking skill pretest

Measured Aspects	Critical Thinking Skill Pretest	
	Control Class	Experimental Class
Mean	13.86	13.83
Maximum Score	19.00	19.00
Minimum Score	8.00	7.00
Standard Deviation	3.40	3.00

Prior to conducting the independent sample t-test, assumption tests were performed. The results

showed that the data were normally distributed (p = 0.200, Kolmogorov–Smirnov test) and variances were homogeneous (p = 0.605, Levene's test). The t-test for the difference between the means yielded a non-significant result (p = 0.753), indicating that there was no statistically significant difference in students' initial critical thinking abilities between the experimental and control groups.

Following the instructional period, the posttest results are summarized in **Table 4**. A substantial increase in critical thinking scores was observed in both groups, particularly in the experimental group, whose mean score rose from 13.83 to 35.33. The control group also improved but to a lesser extent (from 13.86 to 24.36).

Table 4. Descriptive statistics of critical thinking skill posttest

Measured Aspects	Critical Thinking Skill Posttest	
	Control Class	Experimental Class
Mean	24.36	35.33
Maximum Score	27.00	41.00
Minimum Score	19.00	31.00
Standard Deviation	2.45	2.88

A visual comparison of the mean scores between pretest and posttest for both groups is shown in **Figure 1**.

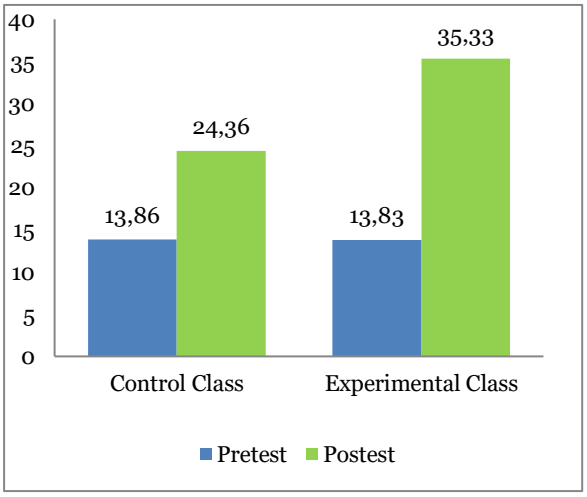

Figure 1. Comparison of Critical Thinking Pretest and Posttest Mean Scores Between Control and Experimental Classes

Inferential testing using an independent sample t-test (**Table 5**) showed a statistically significant difference between the groups (t = -38.453, df = 60, p < 0.001), confirming the effectiveness of the service-learning model in improving students' critical thinking.

Table 5. Independent sample t-test results for critical thinking skill posttest

Variable	t	df	Sig. (2-tailed)	Mean Difference
Critical Thinking Skill	-38.453	60	0.000	-19.96667

The mean difference of -19.97 indicates that the experimental group significantly outperformed the control group. To further measure the magnitude of the intervention's practical impact, an effect size was calculated using Cohen's d. Unlike significance values (p-values), which only indicate whether a difference is likely due to chance, effect size quantifies the practical importance of the difference between two groups. The formula used to compute Cohen's d is as follows:

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

where M_1 is the posttest mean of the experimental group, M_2 is the posttest mean of the control group, and SD_{pooled} is the pooled standard deviation calculated using the formula:

$$SD_{pooled} = \sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}}$$

Based on the data: M_1 = 35.33, M_2 = 24.36, SD_1 = 2.88, SD_2 = 2.45, and n_1=n_2=30, the resulting Cohen's d

was 4.11, which indicates a very large practical effect. This suggests that the use of the service-learning model had a profound and meaningful impact on enhancing students' critical thinking skills in the experimental group.

Students' Collaboration Skills

Prior to the intervention, the initial collaboration skill scores of both groups were comparable. The experimental group had a mean score of 7.76, while the control group scored 7.86, indicating a negligible difference of 0.1 (**Table 6**).

Table 6. Descriptive statistics of initial collaboration skill scores

Measured Aspects	Initial Collaboration Skill Scores	
	Control Class	Experimental Class
Mean	7.86	7.76
Maximum Score	12.00	10.00
Minimum Score	5.00	5.00
Standard Deviation	1.96	1.25

Normality (Kolmogorov–Smirnov, p = 0.200) and homogeneity (Levene's test, p = 0.769) tests confirmed that the data met the assumptions for parametric analysis. An independent sample t-test showed no statistically significant difference in the students' initial collaboration abilities (p = 0.617), confirming the equivalence of both groups at baseline.

After the intervention, the final collaboration scores showed a marked difference between the groups. Students in the experimental class, who participated in the service-learning-based instruction, achieved a mean score of 16.90, while those in the control class obtained a mean score of 13.03, as shown in **Table 7**.

Table 7. Descriptive statistics of final collaboration skill scores

Measured Aspects	Final Collaboration Skill Scores	
	Control Class	Experimental Class
Mean	13.03	16.90
Maximum Score	15.00	20.00
Minimum Score	9.00	15.00
Standard Deviation	2.02	1.62

A visual comparison of the mean initial and final collaboration scores is shown in Figure 2.

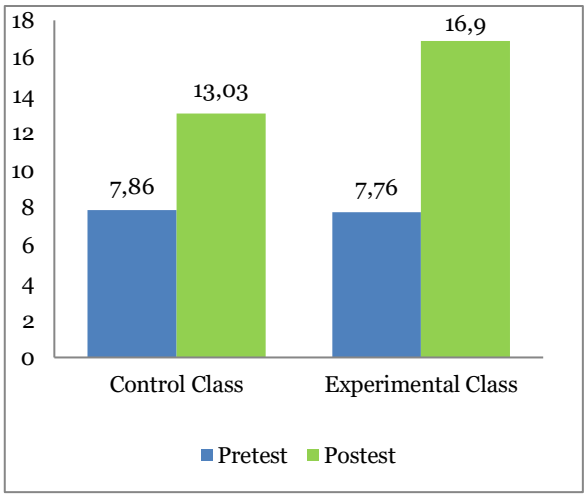

Figure 2. Comparison of initial and final collaboration scores between control and experimental groups

An independent sample t-test was conducted to assess the statistical significance of the observed difference. The result (**Table 8**) revealed a significant effect (t = -3.971, df = 60, p < 0.001), with the experimental group outperforming the control group in terms of collaboration skills.

Table 8. Independent sample t-test results for final collaboration scores

Variable	t	df	Sig. (2-tailed)	Mean Difference
Collaboration Skill	-3.971	60	0.000	-1.9333

In addition to the statistical significance, the practical significance of the difference was examined using Cohen's d. The post-intervention mean score of the experimental group (M_1) was 16.90, compared to

13.03 in the control group (M_2). The standard deviations were $SD_1 = 1.62$ and $SD_2 = 2.02$, respectively, with 30 students in each group ($n_1=n_2$). Based on these values, the calculated Cohen's d was 2.11, which is interpreted as a very large effect size. This indicates that the service-learning model had a substantial and meaningful impact on enhancing students' collaboration skills in the experimental group.

Correlation Between Critical Thinking and Collaboration Skills

To explore the association between students' critical thinking and their collaboration skills, a Pearson product-moment correlation analysis was performed. The analysis used the final scores of both variables, treating critical thinking ability as the predictor (X) and collaboration skill as the outcome variable (Y). Prior to conducting the correlation test, both data sets were examined for normality. The results confirmed that the distribution of scores for each variable met the assumption of normality required for Pearson's correlation.

The results, as presented in **Table 9**, revealed a statistically significant relationship between the two variables, with a *p*-value of 0.000, which is below the accepted significance level of 0.05. This indicates that students with higher critical thinking ability also tended to demonstrate stronger collaboration skills. The Pearson correlation coefficient was 0.994**, suggesting a very strong positive correlation between the two constructs. The double asterisks (**) accompanying the coefficient further indicate that the correlation is significant at the 0.01 level.

Table 9. Result of Pearson bivariate correlation test applying SPSS

		Critical Thinking [X]	Collaboration [Y]
Critical Thinking [X]	Pearson Correlation	1	0,994**
	Sig. (2-tailed)		0,000
	N	60	60
Collaboration [Y]	Pearson Correlation	0,994**	1
	Sig. (2-tailed)	0,000	
	N	60	60

Discussion

This study provides compelling evidence that implementing a service-learning model in biology education, particularly on the topic of viruses, can significantly improve students' critical thinking skills. Through engagement with real-world issues related to viral diseases in their communities, students were encouraged to analyze, interpret, and communicate scientific concepts, fostering the development of higher-order thinking abilities. The opportunities to explore causality, challenge misinformation, and present evidence-based solutions allowed students to apply biology content meaningfully.

These findings are in line with Kennedy and Gruber (2020), who emphasize the potential of the structured phases of service-learning—investigation, preparation, action, reflection, and demonstration—to enhance critical thinking. In this study, students participated in all five phases, resulting in authentic learning experiences that required them to connect classroom knowledge with community-based challenges. The reflection and demonstration stages, in particular, fostered metacognitive engagement and peer evaluation, both of which are fundamental to critical analysis and informed decision-making. The observed outcomes align well with key principles in constructivist and transformative learning theories, including Mezirow's (1990) emphasis on critical reflection for perspective transformation and Dewey's (2008) advocacy for experiential inquiry. Likewise, Ash and Clayton (2009) argue that structured reflection in service-learning bridges theory and practice, making academic content more relevant and impactful—a dynamic clearly observed in this study.

By contrast, students in the control group, who engaged in discovery learning, displayed more modest gains in critical thinking. Although this approach encourages active exploration, its implementation here relied heavily on teacher-directed activities and predefined problems. Students were less involved in addressing open-ended, real-life issues, which may have limited their opportunities for independent inquiry and reasoning. These findings echo critiques from previous studies that note discovery learning, while beneficial for content acquisition, may fall short in fostering the complex reasoning skills required for real-world problem-solving (Hanafiah & Suhana, 2009; Wulandari et al., 2018). The absence of community involvement and structured reflection in discovery learning likely contributed to this outcome.

In addition to critical thinking, this study examined students' collaboration skills as a secondary dependent variable. Initial analysis showed no significant difference between the control and experimental groups at baseline. However, by the end of the intervention, the experimental group showed a marked increase in collaboration ability. This enhancement aligns with Britt (2014), who identifies collaboration as a core benefit of service-learning. Similarly, research by Silcox (1995) and Zhao and Kuh (2004) underscores the role of service-learning in cultivating teamwork, peer support, and collective engagement.

In this study, students involved in service-learning participated in meaningful, context-rich tasks that required them to share responsibilities, negotiate roles, and communicate effectively—skills essential to successful collaboration. The design of the service-learning experience—which involved authentic problems and community interaction—contributed significantly to this development. According to Schank and Halberstadt (2023), such contexts not only promote academic growth but also nurture social and interpersonal competencies. Thus, the improved collaboration observed in the experimental group appears to be a direct outcome of the model's embedded structure.

In contrast, students in the control group, exposed to conventional discovery learning, demonstrated limited growth in collaborative behavior. A likely explanation is the lack of novelty and contextual complexity in their learning tasks. Discovery learning, while allowing for some degree of interaction, typically operates within the classroom and focuses on cognitive goals, often excluding the broader social dynamics required for advanced collaboration. As a result, students had fewer opportunities to engage in sustained, interdependent teamwork, which may explain the modest improvement in their collaborative outcomes.

The study also investigated the relationship between students' critical thinking and collaboration skills. The results revealed a very strong positive correlation ($r = 0.994$, $p < 0.01$). Although such a high correlation is unusual in educational research and may raise questions regarding shared method bias or overlapping constructs, it nonetheless suggests a robust association between the two variables in this context. Students who demonstrated strong collaborative abilities also tended to exhibit high critical thinking performance.

This relationship is supported by a wide body of literature. Hunaidah et al. (2018) observed that collaborative environments naturally promote critical thinking through discussion, clarification, and evaluative dialogue. Johnson and Johnson (2002) similarly argue that social interaction in group work facilitates the integration of new knowledge. The process of articulating ideas, responding to feedback, and co-constructing solutions stimulates higher-order thinking. The findings of this study align with those of Bruner (1985), Totten et al. (1991), and Vygotsky (1978), who stress the importance of sociocultural interaction for cognitive development.

In the context of service-learning, collaboration served not just as a social skill but also as a medium for deep cognitive engagement. Students were required to navigate complex social dynamics, coordinate with community members, and reflect critically on their experiences. As noted by Smith and MacGregor (1992) and Winston and Zimmerman (2003), such environments foster autonomy, critical questioning, and solution-oriented thinking.

Despite these promising findings, several limitations should be acknowledged. First, the study involved a relatively small sample from a single private high school, which limits the generalizability of the results. Second, the duration of the intervention was relatively short, and long-term retention of critical thinking and collaboration skills was not measured. Third, since the same teacher facilitated both learning models, potential teacher bias could not be entirely eliminated, even though efforts were made to maintain instructional consistency.

In conclusion, the service-learning model proved to be an effective pedagogical strategy for enhancing both critical thinking and collaboration skills among high school students. By integrating academic content with real-life application, it promoted deeper learning, active participation, and social responsibility. However, further research is needed with larger, more diverse samples and over extended periods to confirm and expand upon these findings.

CONCLUSION

Based on the findings of this study, several conclusions can be drawn. First, the Service-Learning instructional model was demonstrably effective in enhancing Grade 10 students' critical thinking skills on the topic of viruses. This is evidenced by the results of the independent samples t-test, which revealed a statistically significant difference in posttest scores between the experimental and control groups, favoring the experimental group. The model provided opportunities for students to engage with real-world public health issues, analyze information critically, and formulate evidence-based conclusions—activities that are central to the development of critical thinking.

Second, the Service-Learning model also significantly improved students' collaboration skills. The experimental group outperformed the control group in final collaboration scores, indicating that structured community engagement encouraged students to work interdependently, share responsibilities, manage time collectively, and communicate effectively. These authentic collaborative experiences directly contributed to the enhancement of students' interpersonal competencies.

Third, the study identified a strong positive correlation between students' critical thinking and collaboration skills. These two skill domains appeared to be mutually reinforcing: collaborative activities fostered peer interaction, discussion, and critical reflection, while students' critical thinking abilities enriched

the quality of group dialogue and collective problem-solving. This suggests that Service-Learning not only supports cognitive development and social learning individually but also fosters their integration through authentic, context-driven educational experiences.

REFERENCES

Agustina, E., Ayriza, Y., & Aulia, M. F. (2024). The Relationship Between Reading Culture and Critical Thinking Skills of High School Students. Journal of Innovation in Educational and Cultural Research, 5(4), 615–623. https://doi.org/10.46843/jiecr.v5i4.2070

Alsaleh, N. J. (2020). Teaching Critical Thinking Skills: Literature Review. TOJET: The Turkish Online Journal of Educational Technology, 19(1), 21–39. https://www.tojet.net/articles/v19i1/1913.pdf

Anggrella, D. P., Nurjanah, L., & Sudrajat, A. K. (2024). Development of Critical Thinking and Collaboration Skills in Science Learning at Elementary School: A Case Study. Al Ibtida: Jurnal Pendidikan Guru MI, 11(1), 172–186. https://doi.org/10.24235/al.ibtida.snj.v11i1.14469

Ariizumi, Y. (2025). Creative Ideas for Incorporating Service Learning in Biology and Chemistry Classes. Learning, Teaching, & Researching Optimization. 143. https://scholarsarchive.byu.edu/ltroptimization/143

Ash, S., & Clayton, P. (2009). Generating, Deepening, and Documenting Learning: The Power of Critical Reflection in Applied Learning. Journal of Applied Learning in Higher Education, 01(Fall), 25–48. https://doi.org/10.57186/jalhe_2009_v1a2p25-48

Astiswijaya, N., Kusnandi, K., & Juandi, D. (2023). A Literature Review about One of the Successful Skills of the 21st Century: Collaborative Ability Student. Didaktika Religia, 11(1), 232–254. https://doi.org/10.30762/didaktika.v11i1.3442

Aufa, M. N., Hadi, S., Syahmani, Hasbie, M., Fitri, M., Saputra, M. A., & Isnawati. (2021). Profile of students' critical thinking, creativity, and collaboration skills on environmental pollution material. Journal of Physics: Conference Series, 1760(1). https://doi.org/10.1088/1742-6596/1760/1/012027

Begley, G. S. (2013). Making Connections: Service-Learning in Introductory Cell and Molecular Biology. Journal of Microbiology & Biology Education, 14(2), 213–220. https://doi.org/10.1128/jmbe.v14i2.596

Bernot, K. M., Kulesza, A. E., & Ridgway, J. S. (2017). Service Learning as Inquiry in an Undergraduate Science Course. The American Biology Teacher, 79(5), 393–400. https://doi.org/10.1525/abt.2017.79.5.393

Britt, L. (2014). The Collaborative Benefits of Service-Learning. Partnerships: A Journal of Service-Learning & Civic Engagement, 5(1), 51–71. https://libjournal.uncg.edu/prt/article/view/734

Bruner, J. (1985). Vygotsky: an Historical and Conceptual Perspective Culture, Communication, and Cognition. London: Cambridge University Press.

Capili, B. (2021). Selection of the Study Participants. AJN, American Journal of Nursing, 121(1), 64–67. https://doi.org/10.1097/01.NAJ.0000731688.58731.05

Choi, Y., Han, J., & Kim, H. (2023). Exploring key service-learning experiences that promote students' learning in higher education. Asia Pacific Education Review. https://doi.org/10.1007/s12564-023-09833-5

Cindiati, M., Claudianingrum, H., Ramadhanty, J. A., Suprapto, P. K., & Diella, D. (2021). The Correlation Between Critical Thinking Skills and The Learning Outcomes on Musculoskeletal System. Bioedukasi: Jurnal Pendidikan Biologi, 14(2), 122. https://doi.org/10.20961/bioedukasi-uns.v14i2.49911

Dettmer, P. (2006). New blooms in established fields: Four domains of learning and doing. Roeper Review, 28(2), 70–78. https://doi.org/10.1080/02783190609554341

Dewey, J. (2008). How We Think. New York: Cosimo, Inc.

Dirgatama, C. H. A., Santoso, D., & Ninghardjanti, P. (2016). Penerapan model pembelajaran problem-based learning dengan mengimplementasi program microsoft excel untuk meningkatkan keaktifan dan hasil belajar mata pelajaran administrasi kepegawaian di smk negeri 1 surakarta. JIKAP (Jurnal Informasi Dan Komunikasi Administrasi Perkantoran), 1(1), 36–53. https://doi.org/https://doi.org/10.20961/jikap.v1i1.19138

Dugguh, S. I., Ugochukwu, M. N., Yina, J. M., & Dugguh, F. J. T. (2023). Service-learning Pedagogy: Traceability to Students' Academic Performance in Federal Universities in Nigeria. The International Journal of Business & Management. https://doi.org/10.24940/theijbm/2023/v11/i8/BM2308-025

Ekasani, D., & Kuswinarno, M. (2024). Digital-native workforce strategi pengembangan sdm. Kohesi: Jurnal Sains Dan Teknologi, 5(5), 1–8. https://doi.org/https://doi.org/10.3785/kohesi.v5i5.7598

Farillon, L. M. F. (2022). Scientific Reasoning, Critical Thinking, and Academic Performance in Science of Selected Filipino Senior High School Students. Utamax: Journal of Ultimate Research and Trends in Education, 4(1), 50–62. https://doi.org/10.31849/utamax.v4i1.8284

Firman, F., Nur, S., & Taim, M. A. S. L. (2023). Analysis of Student Collaboration Skills in Biology Learning. Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi, 82–89. https://doi.org/10.33369/diklabio.7.1.82-89

Fitriani, A., Zubaidah, S., & Hidayati, N. (2022). The quality of student critical thinking: A survey of high schools in Bengkulu, Indonesia. JPBI (Jurnal Pendidikan Biologi Indonesia), 8(2), 142–149. https://doi.org/10.22219/jpbi.v8i2.18129

Gronlund, N. E. (1998). Assessment of Student Achievement (9th ed). Boston: Allyn and Bacon.

Halonen, J. S. (2008). Measure for measure: The challenge of assessing critical thinking. In D. S. Dunn, J. S. Halonen, R. A. McCarthy, & D. W. Baker (Eds.), Teaching critical thinking in psychology: A handbook of best practices (pp. 61–76). John Wiley & Sons.

Hanafiah, N. dan Suhana, C. (2009). Konsep Strategi Pembelajaran. Bandung: PT Refika Aditama.

Handoyo, L. D., Paidi, & Suparno, P. (2018). Application of Service-Learning for Developing Curiosity, Responsibility, and Honesty of Biology Education's Students, Sanata Dharma University. Journal of Physics: Conference Series, 1097(1), 012040. https://doi.org/10.1088/1742-6596/1097/1/012040

Huang, X., & Lajoie, S. P. (2023). Social emotional interaction in collaborative learning: Why it matters and how can we measure it? In Social Sciences and Humanities Open (Vol. 7, Issue 1). Elsevier Ltd. https://doi.org/10.1016/j.ssaho.2023.100447

Huitt, W. (1998). Critical thinking: An overview. Educational Psychology Interactive. Valdosta, GA: Valdosta State University. Retrieved June 26, 2025 from, http://www.edpsycinteractive.org/topics/cognition/critthnk.html

Hunaidah, Susantini, E., Wasis, Prahani, B. K., & Mahdiannur, M. A. (2018). Improving Collaborative Critical Thinking Skills of Physics Education Students through Implementation of CinQASE Learning Model. Journal of Physics: Conference Series, 1108(1), 012101. https://doi.org/10.1088/1742-6596/1108/1/012101

Johnson, D. W., and Johnson, F. P. (2002). Joining together: Group theory and group skills (10th ed). Upper Saddle River, NJ: Pearson

Kennedy, H., & Gruber, A. (2020). Critical Thinking in a Service-Learning Course: Impacts of Information Literacy Instruction. Communications in Information Literacy, 14(2), 205–226. https://doi.org/10.15760/comminfolit.2020.14.2.3

Koslowsky, J. et al. (2023). Understanding Service Learning: An Introduction into the Field of Service-Learning Based on the Experiences of the USL Project. Marousi, Greece: Understanding Service-Learning Consortium, Deutsche Schule Athen - European Commission.

Kulesza, A. E., Imtiaz, S., & Bernot, K. M. (2022). Building Connections to Biology and Community through Service-Learning and Research Experiences. Journal of Microbiology & Biology Education, 23(3). https://doi.org/10.1128/jmbe.00082-22

Kumar, S. (2023). Developing Human Skills in the Era of Artificial Intelligence: Challenges and Opportunities for Education and Training. Scholedge International Journal of Multidisciplinary & Allied Studies ISSN 2394-336X, 10(2), 11. https://doi.org/10.19085/sijmas100201

Latif, Y., Kusdaryani, W., & Ariswati, A. (2023). Keterampilan Kolaborasi Peserta Didik dalam Mengikuti Pembelajaran. Prosiding Seminar Nasional Bimbingan dan Konseling tahun 2023 'Inovasi Layanan BK di Era Merdeka Belajar,' 68–78. https://repository.uinsaizu.ac.id/26974/

Listiana, L., Loka, N. M., & Gayatri, Y. (2023). Does student's critical thinking and collaboration skills can empower through investigation and thinking learning strategy? JPBI (Jurnal Pendidikan Biologi Indonesia), 9(3), 315–325. https://doi.org/10.22219/jpbi.v9i3.25118

Machete, P., & Turpin, M. (2020). The Use of Critical Thinking to Identify Fake News: A Systematic Literature Review. In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 12067 LNCS (pp. 235–246). Springer. https://doi.org/10.1007/978-3-030-45002-1_20

Mahanal, S., Tendrita, M., Ramadhan, F., Ismirawati, N., & Zubaidah, S. (2017). The Analysis of Students' Critical Thinking Skills on Biology Subject. Anatolian Journal of Education, 2(2). https://doi.org/10.29333/aje.2017.223a

Mahoney, J. W., & Harris-Reeves, B. (2019). The effects of collaborative testing on higher order thinking: Do the bright get brighter? Active Learning in Higher Education, 20(1), 25–37. https://doi.org/10.1177/1469787417723243

Maulina, D., Priadi, M. A., Gustina, M., & Rakhmawati, I. (2025). Improving Student's Critical Thinking Skills and Sustainability Awareness using Problem Based Learning Model. Jurnal Pendidikan Sains Indonesia, 13(1), 178–188. https://doi.org/10.24815/jpsi.v13i1.42135

Mezirow, J., (1990). How Critical Reflection Triggers Transformative Learning. San Francisco: Jossey Bass Publisher.

Mohzana, Aziz, F., Ridhwan, M., Pramono, S. A., Kusnadi, I. H., & Sakti, B. P. (2025). Analysis of the Effect of Learning Models, Cognitive Abilities, and Facilities on Students' Academic Achievements. Edu Cendikia: Jurnal Ilmiah Kependidikan, 5(01), 169–175. https://doi.org/10.47709/educendikia.v5i01.5725

Montgomery, B. L. (2004). Teaching the Nature of Biotechnology Using Service-Learning Instruction. Bioscience Education, 4(1), 1–12. https://doi.org/10.3108/beej.2004.04000005

Mu'arifah, H., Citraning, R., & Mukaromah, S. (2023). Peningkatan Keterampilan Kolaborasi Siswa dengan

Metode TTS (Tutor Teman Sebaya) pada Mata Pelajaran Biologi. Jurnal Pendidikan Guru Profesional, 1(1), 69–72. https://doi.org/10.26877/jpgp.v1i1.171

Nafisa, D., Sukestiyarno, Y., & Hidayah, I. (2020). Critical Thinking Skill Seen from Curiosity on Independent Learning Assisted by Module. Unnes Journal of Mathematics Education Research, 10(A), 168-174. Retrieved from https://journal.unnes.ac.id/sju/ujmer/article/view/36799

Nuryanti, L., Zubaidah, S., & Diantoro, M. (2018). Analisis Kemampuan Berpikir Kritis Siswa SMP. Jurnal Pendidikan: Teori, Penelitian, & Pengembangan, 3(2), 155–158. https://doi.org/http://dx.doi.org/10.17977/jptpp.v3i2.10490

Nusanti, I. (2014). Strategi Service Learning Sebuah Kajian untuk Mengembangkan Kegiatan Pembelajaran. Jurnal Pendidikan Dan Kebudayaan, 20(2), 251–260. https://doi.org/10.24832/jpnk.v20i2.142

Oktamiasyah, R. & Purwanti. (2025). Berpikir Kritis sebagai Kunci Inovasi Dalam Manajemen Perubahan Organisasi. Journal of Business Economics and Management, 1(03), 315–317.

Oktaviani, A. D., Shoffa, S., & Kristanti, F. (2023). Kemampuan Berpikir Kritis dalam Pembelajaran Matematika melalui Pendekatan Contextual Teaching and Learning. Journal of Education and Teaching (JET), 4(2), 276–282. https://doi.org/10.51454/jet.v4i2.234

Palupi, I. D. R., Ermawati, E., Prayitno, I. M., & Hartatik, R. N. (2023). Improving Collaboration Skills through Problem Based Learning in Elementary School Mathematics. Proceedings of International Conference on Teacher Profession Education Yogyakarta, 29, 772–782. https://seminar.ustjogja.ac.id/index.php/ICoTPE/article/view/971/575

Peterson, S. J., & Schaffer, M. J. (1999). Service learning: a strategy to develop group collaboration and research skills. The Journal of nursing education, 38(5), 208–214. https://doi.org/10.3928/0148-4834-19990501-07

Prentiss, N. K. (2000). Service-Learning in Botany: A Public School Project. In Brubaker, D. C. Ostroff, J. H. (Eds.), Life, Learning, and Community: Concepts and Models for Service-Learning in Biology (AAHE's Series on Service-Learning in the Disciplines) (pp. 31–39). American Association for Higher Education.

Putra, R. A., & Dianastiti, Y. (2023). Kesiapan berwirausaha yang didukung oleh keterampilan berkomunikasi dan keterampilan berpikir kritis bagi siswa teknik otomotif. Jurnal Pendidikan Vokasi Otomotif, 6(1), 71–84. https://doi.org/10.21831/jpvo.v6i1.67852

Rahman, A., Masitoh, S., & Mariono, A. (2022). Collaborative Learning to Improve Creative and Critical Thinking Skills: From Research Design to Data Analysis. International Journal of Educational Review, 4(1), 79–96. https://doi.org/10.33369/ijer.v4i1.22016

Sagala, Y.D.A., Simajuntak, M. P., & Bukit, N. (2019). Implementation of Project-Based Learning (PjBL) in Collaboration Skills and Communication Skills of Students. Proceedings of the 4th Annual International Seminar on Transformative Education and Educational Leadership (AISTEEL 2019), 608–612. https://www.atlantis-press.com/proceedings/aisteel-19/125928462

Saputri, S. S., & Aminatun, T. (2021). The Importance of Improving Collaboration Skill in Confront an Earthquake with Mitigation Learning: A Content Analysis. Proceedings of the 6th International Seminar on Science Education (ISSE 2020), 801–805. https://doi.org/10.2991/assehr.k.210326.115

Sari, T. N. I., Rakhmawati, A., Ratnawati, D., Purwanti, N., & Yulianti, Y. (2025). Quality of critical thinking, communication, collaboration and creativity skills: survey of high school students in biology learning. Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi, 9(1), 41–54. https://doi.org/10.32502/didaktikabiologi.v9i1.185

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), 161–187. https://doi.org/10.32890/mjli2021.18.2.6

Schank, C., & Halberstadt, J. (2023). Teaching Transformative Service Learning. In Transforming Entrepreneurship Education (Vol. 21, Issue 4, pp. 3–21). Springer International Publishing. https://doi.org/10.1007/978-3-031-11578-3_1

Setyowati, E., & Permata, A. (2018). Service Learning: Mengintegrasikan Tujuan Akademik Dan Pendidikan Karakter Peserta Didik Melalui Pengabdian Kepada Masyarakat. Bakti Budaya, 1(2), 143. https://doi.org/10.22146/bb.41076

Shaw, A., Liu, O. L., Gu, L., Kardonova, E., Chirikov, I., Li, G., Hu, S., Yu, N., Ma, L., Guo, F., Su, Q., Shi, J., Shi, H., & Loyalka, P. (2020). Thinking critically about critical thinking: validating the Russian HEIghten® critical thinking assessment. Studies in Higher Education, 45(9), 1933–1948. https://doi.org/10.1080/03075079.2019.1672640

Silcox, H. (1995). The Need to Consider Service Learning in Developing Future Vocational Education Programs. In Kinsley, C. W. & McPherson, K. (Eds.), Enriching the Curriculum Through Service Learning (pp. 24–30). Association for Supervision and Curriculum Development.

Singh, M., & Butola, K. S. (2024). Correlations Between Critical Thinking and Problem-Solving Skills in Critical Situations Among Nursing Students. International Journal of Health Sciences and Research, 14(2), 118–124. https://doi.org/10.52403/ijhsr.20240215

Skrzek-Lubasińska, M., & Malik, R. (2023). Is critical thinking a future skill for business success: science mapping and literature review. Central European Management Journal, 31(1), 48–63.

https://doi.org/10.1108/CEMJ-09-2021-0110
Smith, B. L. & MacGregor, J. T. (1992). What is Collaborative Learning? In Doodsell, A. S. et al. (Eds.), Collaborative Learning: A Sourcebook for Higher Education (pp. 10–30). The National Center on Postsecondary Teaching, Learning, and Assessment. http://files.eric.ed.gov/fulltext/ED357705.pdf
Snyder, L. G., & Snyder, M. J. (2008). Teaching Critical Thinking and Problem-Solving Skills. The Delta Pi Epsilon Journal, 50(2), 90–99. https://eric.ed.gov/?id=EJ826495
Subkoviak, M. J. (1985). Tables of reliability coefficients for mastery tests. 69th Annual Meeting of the American Educational Research Association, 6–10. https://files.eric.ed.gov/fulltext/ED257838.pdf
Subkoviak, M. J. (1988). A Practitioner's Guide to Computation and Interpretation of Reliability Indices for Mastery Tests. Journal of Educational Measurement, 25(1), 47–55. https://www.jstor.org/stable/1435023
Thelma, C. C. (2024). Service Learning and Civic Engagement: Exploring the Linkages. International Journal of Research Publication and Reviews, 4(5), 7056–7064. https://ijrpr.com/uploads/V5ISSUE4/IJRPR25647.pdf
Totten, S., Sills, T., Digby, A., & Russ, P. (1991). Cooperative Learning: A Guide to Research. New York: Garland.
van der Zanden, P. J. A. C., Denessen, E., Cillessen, A. H. N., & Meijer, P. C. (2020). Fostering critical thinking skills in secondary education to prepare students for university: teacher perceptions and practices. Research in Post-Compulsory Education, 25(4), 394–419. https://doi.org/10.1080/13596748.2020.1846313
Varenina, L., Vecherinina, E., Shchedrina, E., Valiev, I., & Islamov, A. (2021). Developing critical thinking skills in a digital educational environment. Thinking Skills and Creativity, 41, 100906. https://doi.org/10.1016/j.tsc.2021.100906
Voehl, F. (2016). Creative thinking. In H. J. Harrington & F. Voehl (Eds.), The innovation tools handbook: Creative tools, methods, and techniques that every innovator must know (Vol. III). CRC Press.
Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.
Winston, G. C. & Zimmerman, D. J. (2003). Peer Effect in Higher Education. Cambridge, MA: National Bureau of Economic Research.
Wulandari, M. D., Sarwi, S., & Yulianto, A. (2018). Development of Discovery Learning Model Using Scientific Approach to Increase Student's Comprehension and Communication Skills Article Info. JISE, 7(2), 223–228. https://doi.org/https://doi.org/10.15294/jise.v7i2.25165
Zhao, C.-M., & Kuh, G. D. (2004). Adding Value: Learning Communities and Student Engagement. Research in Higher Education, 45(2), 115–138. https://doi.org/10.1023/B:RIHE.0000015692.88534.de
Zikrullah, M., & Azhari, A. (2024). The critical thinking research trend in Indonesia's language education journals. Diksi, 32(1), 107–128. https://doi.org/10.21831/diksi.v32i1.72070