The Contribution of Collaboration and Problem-Solving Skills on Cognitive Learning Outcome through Remap-TPS

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Abstract. Collaboration and problem-solving skills can be critical to support students in achieving cognitive learning outcomes because much of the complex work is performed by collaboration. However, there is a dearth of research on the correlation between collaboration, problem-solving skills, on cognitive learning outcomes among high school students. Therefore, this study aimed to investigate the contribution of collaboration and problem-solving skills simultaneously on cognitive learning outcomes. We conducted a correlational study through Reading Concept Mapping-Think Pair Share (Remap-TPS). The sample involved 61 eleventh-grade students in the Natural Sciences majors at Senior High School Malang in 2022/2023. Collaboration skills were assessed using an assessment rubric developed by Greenstein; meanwhile, problem-solving skills and cognitive learning outcomes were assessed using an essay test. We also used multiple regression tests to analyze the data. Our results indicated that: (1) there was a significant correlation between collaboration and problem-solving skills on cognitive learning outcome (0.000<0.05), (2) the contribution of collaboration and problem-solving skills simultaneously on cognitive learning outcome was 31.3%, and (3) the effective contribution of collaboration and problem-solving skills on cognitive learning outcome was 20.7% and 10.6% respectively, (4) the regression equation of collaboration and problem-solving skills and cognitive learning outcome is $Y = 68.307 + 0{,}192*X_1 + 0.060*X_2$. These findings concluded that there was a correlation between collaboration and problem-solving skills on cognitive learning outcomes. Furthermore, teachers could consider Remap-TPS for senior high school students to empower collaboration and problem-solving skills that may significantly contribute to cognitive learning outcomes.

Keywords: Cognitive Learning Outcome, Collaboration, Problem-solving, Remap-TPS.

1. Introduction

Collaboration skills have been recognized as essential for students working together to solve problems [1]. Collaboration occurs when more than one student can manage and

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collect resources with the group to achieve the learning outcome [2]. Collaboration has been analyzed not only as a learning mechanism but also as a learning outcome [3]. The character of students with collaboration skills can be identified through how they can plan, communicate, contribute, support, monitor, and make decisions with the group [4]. However, collaboration also needs problem-solving skills to solve the widespread problem today [5].

Problem-solving skills are often challenging for students because they encounter complex daily problems [6]. Several studies showed that problem-solving skills significantly affect the learning outcome and improve self-efficacy [7]. Specifically, problem-solving also affects students' motivation and adjustment [8]. Problem-solving skills can also significantly increase scientific knowledge, concepts, and problem-solving abilities [9]. Those studies showed that problem-solving skills contribute to improving cognitive learning outcomes.

Students are expected to achieve learning outcomes regarding knowledge, skills, and competencies [10]. Cognitive learning outcomes have been emphasized for students because students should understand each topic to reach academic achievement [11]. Cognitive learning outcomes have been identified as essential quality dimensions in the classroom. Teachers should improve students' cognitive learning outcomes through teaching thinking skills [10]. Thus, exploring factors to enhance cognitive learning outcomes should be conducted [12].

Several studies have attempted to correlate cognitive learning outcomes with other thinking skills. Yu et al. [12] showed correlations between motivation, learning strategies, and learning outcomes. Bahri & Corebima [13] showed a correlation between learning motivation and metacognitive skills to cognitive learning outcomes. Moreover, Amin [14] also stated that there was a correlation between metacognitive skills and critical thinking skills. Siburian et al. [15] also found a correlation between critical and creative thinking skills and cognitive learning outcomes. Therefore, exploring other thinking skills that contribute to cognitive learning outcomes is needed through the appropriate learning model.

Various studies have shown that students' thinking skills, such as reading, concept, and mapping (Remap), can be empowered the learning process. Remap is an active learning strategy that can enhance thinking skills [16]. However, a learning model that is facilitated not only empowers their thinking but also allows all students to collaborate on their thinking and discuss their ideas is needed. A learning model that can encourage students to think and discuss is TPS, which has three stages: think, pair, and share [17]. When implementing TPS, the teachers first asked the students questions, giving them time to think individually about questions, often encouraging them to write down their ideas. Then, students pair up with other students to discuss the answer [16]. Therefore, combining Remap and TPS to foster collaboration and problem-solving skills is needed. In general, several studies showed a correlation between cognitive learning outcomes and other thinking skills. However, there is a dearth of research on the correlation between collaboration, problem-solving skills, on cognitive learning outcomes, especially for high school students. Based on the potency of Remap and TPS, we combine Remap-TPS to activate their collaboration and problem-solving to improve students' cognitive learning outcomes. Thus, this study aimed to investigate the

contribution of collaboration and problem-solving skills simultaneously on cognitive learning outcomes through Remap-TPS. This integration was conducted to maximize the improvement of students' cognitive learning outcomes, collaboration, and problem-solving.

2. Method

We conducted the correlational study in grade 11 science from September to October at Senior High School in Malang. The sample was determined using a random sampling technique, which consisted of two classes involving 61 students. Twenty-eight students participated in the experimental class, and thirty-three students participated in the control class. Collaboration skills were assessed using an assessment rubric developed by Greenstein [18]; meanwhile, problem-solving skills and cognitive learning outcomes were assessed using an essay test. The instrument's validity was measured through validation from three experts, whereas reliability was calculated using Cronbach's Alpha, and the value was 0.753. Data were analyzed using SPSS version 22 software. Then, the Kolmogorov-Smirnov test was used to determine data normality, whereas the Levene test was used to determine the homogeneity and to test the hypothesis using multiple regression analysis (alpha = 5%).

3. Results and Discussion

Based on the results, the data were normal, homogeneous, and linear, so it can be continued using multiple regression analysis to determine the correlation between each variable. The results of multiple regression analysis showed that collaboration and problem-solving skills strongly correlate with cognitive learning outcomes with a signification of 0.000<0.05 (Table 1). Then, the multiple regression analysis also showed the value of the regression coefficient (R) is 0.559, and the determination coefficient is (R^2) 0.313. The coefficient value showed that the contribution of collaboration and problem-solving skills on cognitive learning outcome is 31.30%, while other factors are 68.7%. The coefficient value indicated that collaboration skills and problem-solving skills influenced students' cognitive learning outcomes.

Table 1. Multiple Regression Analysis on Simultaneous Correlations Between Collaboration and Problem-Solving Skills

Model		Sum of Squares	df	Mean Square	F	Sig.	R	R Square
1	Regression	143.770	2	71.885	13.197	0.000	0.559[a]	0.313
	Residual	315.939	58					
	Total	459.709	60					

Then, we analyzed the correlation of each skill on cognitive learning outcomes. Table 2 showed a significant correlation between collaboration and problem-solving skills to cognitive learning outcomes with the equation $Y = 68.307 + 0.192X_1 +$

$0.060X_2$, Y is cognitive learning outcomes, X_1 is collaboration skills, X_2 is problem-solving skills. The significant value of collaboration skills was $0.001<0.05$, whereas the significant value of problem-solving skills was $0.002<0.05$. The significant value proved a correlation between collaboration skills, problem-solving skills, and cognitive learning outcomes.

Table 2. Multiple Regression Analysis on The Partial Correlation between Collaboration Skills and Problem-Solving Skills

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	68.307	3.547		19.255	0.000		
	Collaboration	0.192	0.054	0.412	3.570	0.001	0.888	1.126
	Problem-Solving Skills	0.060	0.028	0.264	2.288	0.002	0.888	1.126

Moreover, we also calculated the relative and effective contribution of the independent variables to the dependent variable. Table 3 shows that the relative contribution of collaboration skills on cognitive learning outcomes is 66.13%, and the relative contribution of problem-solving skills on cognitive learning outcomes is 33.87%. The effective contribution of collaboration skills to cognitive learning outcomes is 20.7%, and the effective contribution of problem-solving skills to cognitive learning outcomes is 10.6%. Thus, the total effective contribution is 31.3%. Therefore, it can be concluded that collaboration skill has a more significant contribution than problem-solving skills on cognitive learning outcome.

Table 3. Contribution of Collaboration and Problem-Solving Skills on Cognitive Learning Outcome

Variable	RC (%)	EC (%)
X1 Collaboration Skills	66.13	20.7
X2 Problem-Solving Skills	33.87	10.6
Total	100	31.3

Note: RC = Relative Contribution, EC = Effective Contribution

The results showed a significant correlation between collaboration and problem-solving skills on cognitive learning outcomes through the Remap-TPS learning model. These results indicated that the Remap-TPS model affects collaboration skills, problem-solving skills, and cognitive learning outcomes. In this study, Remap-TPS was facilitated by the website Wizer.me and the mindmup application to help students collaborate to solve problems by compiling mindmap. Several studies also showed that the Remap-TPS learning model can enhance collaboration, problem-solving, and cognitive learning outcomes because of the activities in Remap-TPS. The learning stages in Remap-TPS consist of five stages. There are reading, concept mapping, thinking, pairing, and sharing.

The first, stage of the Remap-TPS learning model begins with reading activities. Reading activity is used to facilitate an understanding of the topic [19], develop comprehension understanding [20], and generate ideas [21]. Students get a lot of information and are ready to follow learning through reading activities. In addition, reading activities also contribute to motivating students [22]. *The second*, stage of the Remap-TPS learning model is concept mapping activities. Concept mapping activities were conducted by using the mindmup application. Concept mapping can facilitate students to identify problems and understand complex concepts [23], improve cognitive and memory abilities [24], and improve their thinking skills and creativity by systematically organizing information [25]. The concept mapping results are completed by students reflecting on their learning (Figure 3). In addition, using colors and images in concept maps through the application can improve memory, interpret concepts, organize ideas, and facilitate understanding to make learning meaningful [26].

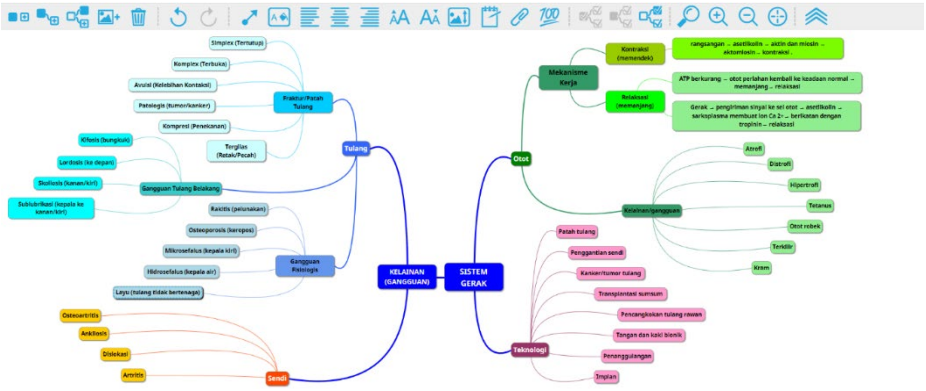

Fig. 1. Example of Concept Mapping Assisted by The Student Mindmup Application on Motion Systems

Translation for Picture 1

Kelainan: Disease	Penggantian sendi: Joint Replacement	Tulang: Bone
Sistem Gerak: Movement System	Kanker tulang: Bone Cancer	Patah tulang: Broken Bones
Otot: Muscle	Transplantasi sumsum: Bone Marrow Transplant	Simplex: Simplex
Mekanisme kerja: Work Mechanism	Pecangkokan tulang rawan: Cartilage Graft	Komplex: Komplex
Kontraksi: Contraction	Tangan dan kaki bionik: Bionic Arms and Legs	Avulsi: Avulsion
Relaksasi: Relaxation	Penanggulangan: Countermeasures	Kompresi: Compression
Artitis: Arthritis	Gangguan tulang belakang: Spinal Disorders	Retak: Cracked

Atrofi: Arthrofi	Gangguan fisiologi: Physiological Disorders	Kifosis: Kyphosis
Distrofi: Dystrophy	Rakitis: Rickets	Lordosis: Lordosis
Hipertrofi: Hypertrophy	Osteoporosis: Osteoporosis	Skoliosis: Scoliosis
Tetanus: Tetanus	Mikrosefalus: Microcephaly	Sublubrikasi: Sublubrication
Otot robek: Torn Muscle	Hidrosefalus: Hydrocephalus	Dislokasi: Dislocation
Terkilir: Sprained	Layu: Withered	Rangsangan: Stimulation
Kram: Cramps	Sendi: Joints	Asetilkolin: Acetylcholine
Teknologi: Technology	Osteoartritis: Osteoarthritis	Aktin: Actin
Implan: Implant	Ankilosis: Ankylosis	Aktomiosis: Aktomyosis
ATP berkurang: ATP decreases	Otot kembali normal: Muscle returns to normal	Memanjang: Lengthens
Gerak: Movement	Mengirim sinyal ke otot: Send signals to muscle	Berikatan dengan tropin: Binds to tropine
Miosin: Myosin	Sarkoplasma membuat ion Ca^{2+}: Sarcoplasm makes Ca^{2+} ions	

The third stage of the Remap-TPS learning model is thinking activities. Thinking activities are stages where students identify problems by asking questions. Thinking activities are carried out through the website Wizer.me to help them think independently to identify problems [27]. The fourth stage of the Remap-TPS learning model is pair activities. Pair activities are stages where students identify solutions by looking for several reference sources. Pair activities are carried out by collaborating with other students to solve the problems that have been identified. The fifth stage of the Remap-TPS learning model is sharing activities. Sharing activities are stages of evaluating and defending solutions in a discourse to solve problems [28]. The Wizer.me website played a significant role in the Remap-TPS activity because it facilitates the student learning process to compile and solve problems. In line with another study, learning using websites can provide opportunities for them to use technology in learning so that learning is not boring [29]. Asrar et al. [30] reported that learning through interactive multimedia media can improve students' problem-solving skills and cognitive learning outcomes [31]. Technology in learning helps them easily obtain broader information [32].

Based on the results, students' cognitive biology learning outcomes correlate positively with collaboration skills, problem-solving skills, and cognitive learning outcomes through Remap-TPS. Collaboration skills and problem-solving skills can affect cognitive learning outcomes because discussion activities in pairs and sharing the results of solutions with other groups can trigger students to gain more knowledge [33]. The use of technology when discussing also can develop their thinking skills and generate ideas to provide solutions related to problem-solving [34]. During discussion activities, students are trained to be responsible for finding solutions [35] and respect each other's opinions which can provide positive energy to people [36]. Collaboration with other groups can allow students to evaluate the answers [37], and collaboration to solve problems in learning affects their cognitive learning outcomes. The use of technology in learning has a positive impact on promoting active learning. Thus, empowering 21st-

century skills, especially collaboration and problem-solving skills, positively impacts students' cognitive learning outcomes.

The findings suggest that educators use Remap-TPS, assisted by the Wizer.me website and the mindmup application in teaching practices effectively to facilitate students' collaboration skills, problem-solving skills, and cognitive learning outcomes. This study provides a valuable resource for teachers to increase their students understanding of biology material using the website Wizer.me. Overall, the research results inform that the effective use of technology in teaching supports the development of 21st-century skills. However, there are some limitations in this research. First, future studies can evaluate the contribution of collaboration skills and problem-solving skills with different learning models. Second, further studies can determine the Remap-TPS model to improve other thinking skills. Furthermore, we recommended that teachers and researchers use Remap-TPS for senior high school students to empower collaboration and problem-solving skills that may significantly contribute to cognitive learning outcomes.

4. Conclusion

All in all, our results indicated that: (a) there was a significant correlation between collaboration and problem-solving skills on cognitive learning outcome ($0.000<0.05$), (b) the contribution of collaboration and problem-solving skills simultaneously on cognitive learning outcome was 31.3%, and (c) the effective contribution of collaboration and problem-solving skills on cognitive learning outcome was 20.7% and 10.6% respectively, (d) the regression equation of collaboration and problem-solving skills and cognitive learning outcome is $Y=68.307+0,192*X_1+0.060*X_2$. These findings concluded that there was a correlation between collaboration and problem-solving skills on cognitive learning outcomes. These findings also recommend Remap-TPS facilitated with website Wizer.me and mindmup to enhance collaboration, problem-solving skills, and cognitive learning outcomes. Moreover, teachers could consider Remap-TPS for senior high school students to empower collaboration and problem-solving skills that may significantly contribute to cognitive learning outcomes. Further research is needed to reveal the correlation between other thinking skills contributing to cognitive learning outcomes with different populations and instruments.

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References

1. Care, E., Scoular, C., Griffin, P.: Assessment of Collaborative Problem Solving in Education Environments. Applied Measurement in Education. 29, 250–264 (2016). https://doi.org/10.1080/08957347.2016.1209204.

2. Nemiro, J.E.: Building Collaboration Skills in 4th- to 6th-Grade Students Through Robotics. Journal of Research in Childhood Education. 35, 351–372 (2021). https://doi.org/10.1080/02568543.2020.1721621.
3. Child, S.F.J., Shaw, S.: Towards an operational framework for establishing and assessing collaborative interactions. Research Papers in Education. 34, 276–297 (2019). https://doi.org/10.1080/02671522.2018.1424928.
4. Newell, C., Bain, A.: Team-based collaboration in higher education learning and teaching: A review of the Literature. Springer, Singapore (2018).
5. R. Kelley, T., Geoff Knowles, J., Han, J., Sung, E.: Creating a 21st Century Skills Survey Instrument for High School Students. EDUCATION. 7, 583–590 (2019). https://doi.org/10.12691/education-7-8-7.
6. Yu, K.-C., Fan, S.-C., Lin, K.-Y.: Enhancing Students' Problem-Solving Skills Through Context-Based Learning. International Journal of Science and Mathematics Education. 13, 1377–1401 (2015). https://doi.org/10.1007/s10763-014-9567-4.
7. Armağan, F.Ö., Sağır, Ş.U., Çelik, A.Y.: The effects of students' problem-solving skills on their understanding of chemical rate and their achievement on this issue. Procedia - Social and Behavioral Sciences. 1, 2678–2684 (2009). https://doi.org/10.1016/j.sbspro.2009.01.473.
8. de la Fuente, A., Cardeñoso, O., Chang, E.C., Lucas, A.G., Li, M., Chang, O.D.: The role of problem-solving ability, beyond academic motivation, in college students' psychological adjustment. Curr Psychol. 42, 17888–17897 (2023). https://doi.org/10.1007/s12144-022-02945-y.
9. Cheng, S.-C., She, H.-C., Huang, L.-Y.: The Impact of Problem-Solving Instruction on Middle School Students' Physical Science Learning: Interplays of Knowledge, Reasoning, and Problem Solving. EURASIA J MATH SCI T. 14, (2017). https://doi.org/10.12973/ejmste/80902.
10. Dias, D.: Learning Outcomes in European Higher Education. In: Teixeira, P.N. and Shin, J.C. (eds.) The International Encyclopedia of Higher Education Systems and Institutions. pp. 1996–2000. Springer Netherlands, Dordrecht (2020). https://doi.org/10.1007/978-94-017-8905-9_317.
11. Burston, J.: Twenty years of MALL project implementation: A meta-analysis of learning outcomes. ReCALL. 27, 4–20 (2015). https://doi.org/10.1017/S0958344014000159.
12. Yu, Z., Xu, W., Sukjairungwattana, P.: Motivation, Learning Strategies, and Outcomes in Mobile English Language Learning. The Asia-Pacific Education Researcher. 32, 545–560 (2023). https://doi.org/10.1007/s40299-022-00675-0.
13. Bahri, A., Corebima, A.D.: The Contribution of Learning Motivation And Metacognitive Skill On Cognitive Learning Outcome Of Students Within Different Learning Strategies. JBSE. 14, 487–500 (2015). https://doi.org/10.33225/jbse/15.14.487.
14. Amin, A.M., Duran, A., Zubaidah, S., Mahanal, S.: The Correlation between Metacognitive Skills and Critical Thinking Skills at the Implementation of Four Different Learning Strategies in Animal Physiology Lectures. EUROPEAN J ED RES. 9, 143–163 (2019). https://doi.org/10.12973/eu-jer.9.1.143.
15. Sıburıan, J., Corebima, A.D., Ibrohim, Saptasarı, M.: The Correlation Between Critical and Creative Thinking Skills on Cognitive Learning Results. JOR. 19, 99–114 (2019).
16. Corebima, A.D., Saputri, W.: The Correlation between Metacognitive Skills and Cognitive Learning Results of Biology Pre-service Teacherson Different Learnings. tused. 17, 487–503 (2020). https://doi.org/10.36681/tused.2020.40.
17. Cohen, M., Buzinski, S.G., Armstrong-Carter, E., Clark, J., Buck, B., Reuman, L.: Think, pair, freeze: The association between social anxiety and student discomfort in the active

learning environment. Scholarship of Teaching and Learning in Psychology. 5, 265–277 (2019). https://doi.org/10.1037/stl0000147.
18. Greenstein, L.: Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning. In Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning. Corwin, A Sage Company, California (2012).
19. Zubaidah, S., Mahanal, S., Rosyida, F., Kurniawati, Z.L.: Using remap-TmPS learning to improve low-ability students' critical thinking skills. Asia-Pacific Forum on Science Learning and Teaching. 19, 30 (2018).
20. Tavsancil, E., Yildirim, O., Demir, S.B.: Direct and Indirect Effects of Learning Strategies and Reading Enjoyment on PISA 2009 Reading Performance. EJER. 19, 1–22 (2019). https://doi.org/10.14689/ejer.2019.82.9.
21. Irawan, F., Adawiyah, R., Zubaidah, S., Arsih, F.: Scientific literacy and communication skills are significant for enhancing students' creative thinking skills. In: AIP Conference Proceedings. pp. 1–8., Malang, Indonesia (2023). https://doi.org/10.1063/5.0112412.
22. Adawiyah, R., Irawan, F., Zubaidah, S., Arsih, F.: The relationship between creative thinking skills and learning motivation in improving student learning outcomes. In: AIP Conference Proceedings. pp. 1–8., Malang, Indonesia (2023). https://doi.org/10.1063/5.0112425.
23. Patrick, A.O.: Concept Mapping s a Study Skill: International Journal of Educational Sciences. 3, 49–57 (2011). https://doi.org/10.1080/09751122.2011.11890008.
24. Leeds, A.J., Kudrowitz, B., Kwon, J.: Mapping associations: exploring divergent thinking through mind mapping. International Journal of Design Creativity and Innovation. 7, 16–29 (2019). https://doi.org/10.1080/21650349.2018.1463178.
25. Wang, A.Y.: Exploring the relationship of creative thinking to reading and writing. Thinking Skills and Creativity. 7, 38–47 (2012). https://doi.org/10.1016/j.tsc.2011.09.001.
26. Adodo, S.O.: Effect of Mind-Mapping as a Self-Regulated Learning Strategy on Students' Achievement in Basic Science and Technology. MJSS. 4, 163–172 (2013). https://doi.org/10.5901/mjss.2013.v4n6p163.
27. Farkhati, A., Sumarti, S.S.: Implementasi Manajemen Pembelajaran Kimia Berbantuan E-Lkpd Terintegrasi Chemoentrepreneurship untuk Menganalisis Soft Skill Siswa. Journal of Chemistry in Education. 8, 1–5 (2019).
28. Mispa, R., Putra, A.P., Zaini, M.: Penggunaan Lembar Kerja Peserta Didik Elektronik (E-LKPD) Live Worksheet pada Konsep Protista terhadap Hasil Belajar Peserta Didik Kelas X SMAN 7 Banjarmasin. Jurnal Pendidikan Indonesia (Japendi). 3, 2134–2145 (2022).
29. Putri, V.A.R., Delia, I.: Pengembangan Media Evaluasi Pembelajaran Bilangan Berpangkat Tiga dan Akar Pangkat Tiga Berbantuan Wizer.me Untuk Siswa Sekolah Dasar. JPGSD. 9, 3542–3550 (2021).
30. Asrar, A., Yerizon, Arnawa, I.M., Permana, D.: Pengembangan Lembar Kerja Peserta Didik Elektronik Berbasis Problem Based Learning untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik Kelas X SMA Negeri 1 Panti. JEMS (Jurnal Edukasi Matematika dan Sains). 11, 182–190 (2023). https://doi.org/10.25273/jems.v11i1.14361.
31. Janah, M.: Efektifitas Model Pembelajaran Problem Based Learning (Pbl) Berbasis E-Worksheet untuk Meningkatkan Hasil Belajar dan Keaktifan Siswa. Prosiding NASCA. 160–167 (2020). https://doi.org/10.47387/nasca.v1i1.28.
32. Sobri, M., Indraswati, D., Rahmatih, A.N., Fauzi, A., Amrullah, L.W.Z.: Pelatihan Pembuatan Worksheet Interaktif Dengan Wizer.Me untuk Mengoptimalkan Pembelajaran di SD Negeri 26 Mataram. Jurnal Warta Desa (JWD). 4, 118–124 (2022). https://doi.org/10.29303/jwd.v4i2.189.

33. Tivani, I., Paidi, P.: Pengembangan LKS biologi berbasis masalah untuk meningkatkan kemampuan pemecahan masalah dan karakter peduli lingkungan. JIPI. 2, 35–45 (2016). https://doi.org/10.21831/jipi.v2i1.8804.
34. Simatupang, H., Ionita, F.: Pengaruh Model Problem Based Learning terhadap Kemampuan Pemecahan Masalah Materi Pencemaran Lingkungan Siswa Sma Negeri 13 Medan. Biolokus. 3, 245–251 (2020). https://doi.org/10.30821/biolokus.v3i1.680.
35. Cheruvelil, K.S., De Palma-Dow, A., Smith, K.A.: Strategies to Promote Effective Student Research Teams in Undergraduate Biology Labs. The American Biology Teacher. 82, 18–27 (2020). https://doi.org/10.1525/abt.2020.82.1.18.
36. Husen, A., Indriwati, S.E., Lestari, U.: Peningkatan Kemampuan Berpikir Kritis dan Keterampilan Proses Sains Siswa SMA melalui Implementasi Problem Based Learning Dipadu Think Pair Share. Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan. 2, 853–860 (2017).
37. Surayya, L., Subagia, I.W., Tika, I.N.: Pengaruh Model Pembelajaran Think Pair Share terhadap Hasil Belajar Ipa Ditinjau dari Keterampilan Berpikir Kritis Siswa. e-Journal Program Pascasarjana Universitas Pendidikan Ganesha. 4, 11 (2014).