

The Effect of a Problem-Based Learning (PBL) Model Integrated with Mind Mapping on The Learning Motivation of Grade X Students

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Abstract: Low student motivation for learning in the biology curriculum remains a challenge that calls for innovative instructional approaches. One alternative is the Problem-Based Learning (PBL) model integrated with the Mind Mapping technique, which is believed to promote active engagement and improve students' understanding. This study aimed to examine the effect of a Problem-Based Learning (PBL) model integrated with Mind Mapping on students' learning motivation regarding water pollution among Grade X students at MA Miftahul Ulum Bettet Pamekasan. The study employed a quantitative, quasi-experimental design with a post-test-only control group. The sample consisted of two classes: an experimental class that implemented PBL integrated with Mind Mapping and a control class that used the lecture method, each with 25 students. The research instrument was a learning motivation questionnaire. Data were analyzed using tests of normality and homogeneity, and an independent-samples t-test in Jamovi version 2.3.26. The results indicated a p-value of 0.705 ($p > 0.05$), indicating no statistically significant difference in learning motivation between the experimental and control groups. Therefore, it can be concluded that implementing Problem-Based Learning integrated with Mind Mapping did not have a significant effect on students' learning motivation. Nevertheless, this model is still recommended as an innovative instructional strategy that may enrich students' learning experiences.

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Introduction

Education in Indonesia is currently developing rapidly, with various reforms implemented to improve both the quality and quantity of existing education. Improving educational quality requires breakthroughs in curriculum development, instructional innovation, and the provision of educational facilities and infrastructure (Kurniawati, 2022). In line with these developments, creating high-quality education is a crucial priority because the progress of a society or nation is highly dependent on the quality of its education. Accordingly, education serves as a medium for developing skills, shaping character, and building a dignified national civilization. This aligns with the national education goals: to educate the nation and develop learners' potential so that they become individuals who are faithful and devoted to God Almighty, have noble character, are healthy, knowledgeable, competent, creative, independent, and become democratic and responsible citizens for themselves and their country (Alifah, 2021).

A major problem in contemporary formal education (schools) is students' low level of engagement in understanding, remembering, and applying the learning materials they receive in class. This is reflected in students' average learning outcomes, which remain concerning, largely because learning conditions do not sufficiently engage students' interest and because instruction is

still predominantly teacher-centered (Syaadah, 2023). Based on observations at MA Miftahul Ulum Bettet Pamekasan conducted on 28 September 2024 and 17 January 2025, some students were still found to be unfocused during lessons and indifferent to classroom learning. Of 25 students, 15 remained silent during the learning process, while only 10 appeared truly focused. This indicates that students' motivation remained suboptimal. Student learning motivation is also an important consideration, as is the instructional model used. In biology classes, teachers tend to dominate instruction, while students mainly listen to the teacher's explanations. To address low student learning absorption, one alternative is the Problem-Based Learning (PBL) model, which trains students to think critically and understand content more deeply (Meilasari et al., 2020).

Problem-Based Learning (PBL) has been widely recognized as an effective method for improving students' learning outcomes and learning motivation (Asmaliyah et al., 2025; Nafisah et al., 2025). Unlike traditional teacher-centered approaches, PBL is student-centered (Cong & Ironsi, 2025). In this model, students are confronted with complex, real-world problems that require investigation, collaboration, and critical analysis to arrive at solutions (Siswanto et al., 2025; Muñoz Alvarez et al., 2025; Lu, Mustakim, & Muhamad, 2025). PBL is well-suited to biology learning because biology is not only about theories and concepts; it also requires doing, exploring, and solving problems related to biological phenomena. Through PBL, learners use a problem case as a trigger to determine their own learning objectives (Šliogerienė et al., 2025; Amirudin et al., 2025; Khadijah et al., 2025). They then learn independently and return to the group to discuss and refine their understanding. Thus, PBL is not merely about problem solving; it uses appropriately selected problems to enhance knowledge and understanding while making students active participants in the learning process (Lonita & Simatupang, 2020). However, during discussions and content comprehension, students often struggle to organize complex information. Therefore, Mind Mapping is used in this study because it is believed to help students understand extensive learning materials and can be created in a way that students enjoy, tailored to their preferences. Mind Mapping may also help address students' comprehension difficulties (Karnila Widiastuti & Fitrotun Nisa, 2024). PBL integrated with Mind Mapping has also been reported to increase students' learning motivation (Firdaus et al., 2022).

According to Firdaus et al. (2022), Problem-Based Learning integrated with Mind Mapping can stimulate students' learning motivation and provide feedback that supports the achievement of learning outcomes. Motivation is an internal process that continuously activates, directs, and sustains behavior. Learning motivation plays a major role in student success. It may be defined as a driving force for certain activities that originates both from within and outside the individual, thereby fostering enthusiasm for learning (Djarwo, 2020). Learning outcomes are optimal when learning motivation is present; the more appropriate the motivation, the better the learning outcomes. Thus, motivation determines the intensity of students' learning efforts (Agrifina et al., 2024). Accordingly, the influence of the PBL method combined with Mind Mapping in biology learning needs to be examined. Therefore, this study aimed to determine the effect of integrating PBL and Mind Mapping on students' learning motivation.

Research Method

Research Design

This study employed a quasi-experimental research design (Rosas et al., 2025) within a quantitative research approach (Alford & Teater, 2025), using a post-test-only control group design (Krishnan, 2025). The study aimed to examine the effect of the Problem-Based Learning model on learning motivation at MA Miftahul Ulum Bettet Pamekasan by investigating the relationship between the independent variable (X) and the dependent variable (Y). The research design is presented in Table 1.

Table 1. Research Design

Group	Treatment	Observation
Experimental	X1	O1
Control	X2	O2

Notes:

X1: Learning using the Problem-Based Learning (PBL) model integrated with mind mapping.

X2: Learning using the lecture (conventional) method.

O1: Learning motivation of students in the experimental class before and after implementing PBL integrated with Mind Mapping.

O2: Learning motivation of students in the control class before and after implementing the lecture method.

Data Collection Instruments

The instructional devices used included the Learning Objectives Flow (Alur Tujuan Pembelajaran/ATP), teaching modules, Student Worksheets (LKPD), an observation sheet for implementing PBL syntax, and test instruments (Mulyani et al., 2025). The instrument for measuring learning motivation was a Likert-scale motivation questionnaire (Tanujaya et al., 2022) containing indicators such as task value, intrinsic and extrinsic goal orientation, self-efficacy, and control of learning (Adawiyah et al., 2023). The content validity of all instructional devices and the motivation questionnaire was evaluated through expert judgment by lecturers and the subject teacher (Hendryadi, 2017). The internal reliability of the motivation questionnaire was then analyzed using Cronbach's alpha coefficient to ensure inter-item consistency (Croasmun & Ostrom, 2011).

Data Analysis

Learning motivation data were analyzed quantitatively using descriptive statistics to describe the motivation profile for each group before inferential testing (de Souza et al., 2024). Assumption tests included the Shapiro–Wilk normality test and Levene's test for homogeneity of variances (Ghasemi & Zahediasl, 2012). Differences in mean learning motivation between the two groups were examined using a two-tailed independent-samples t-test with a significance level of 0.05 (Vrbin, 2022). All analyses were conducted using Jamovi version 2.3.26 (Caldwell, 2022).

Result and Discussion

The data in this study were obtained from Grade X students at MA Miftahul Ulum Bettet Pamekasan (N = 37). The sample was divided into two groups: 19 students in the experimental class and 18 students in the control class. This section presents the research findings based on the analysis of post-test data. Table 2 provides descriptive statistics of students' learning motivation in the control and experimental classes based on post-test scores. Descriptive statistics were used to provide an initial overview of central tendency (mean and median) and data dispersion (SD and SE) for each group, serving as a basis for inferential analysis.

Table 2. Descriptive Statistics of Learning Motivation

Variable	Group	N	Mean	Median	SD	SE
Motivation	Control	18	72.3	72.2	8.09	1.91
	Experimental	19	71.2	72.8	10.4	2.39

Overall, the mean learning motivation score in the control class (Mean = 72.3) and the experimental class (Mean = 71.2) were relatively similar, with comparable medians. However, the experimental class showed greater variability (SD = 10.4) than the control class (SD = 8.09), indicating higher heterogeneity of learning motivation in the experimental group. The SE values for both groups were within a reasonable range, suggesting that the mean in each group adequately represents the central tendency.

Before testing the hypothesis, the learning motivation data were examined for the normality assumption. Normality testing aims to ensure that the distribution of learning motivation scores meets the prerequisites for parametric analysis, particularly when using mean-difference tests (e.g., t-tests) on post-test data (Table 3).

Table 3. Normality Test Results for Learning Motivation

Variable	W	p
Motivation	0.975	0.548

The normality test results showed $p = 0.548 (> 0.05)$ with $W = 0.975$; therefore, the learning motivation data can be considered normally distributed. This indicates that the normality assumption is met, and the analysis proceeded to the homogeneity test (Table 4).

Table 4. Homogeneity Test Results for Learning Motivation

Variable	F	df	df2	p
Motivation	2.52	1	35	0.121

Table 4 shows a significance value of 0.121, which is greater than 0.05. This indicates that students' learning motivation is homogeneous across groups. With the homogeneity assumption satisfied, the data were deemed suitable for further analysis using parametric statistics (Table 5).

Table 5. Independent-Samples t-Test Results for Learning Motivation

Variable	t statistic	df	p
Motivation	0.382	35.0	0.705

Table 5 shows $p = 0.705 (p > 0.05)$, indicating that there was no statistically significant difference between the mean learning motivation scores of the two classes. In other words, PBL integrated with Mind Mapping did not have a significant effect on students' learning motivation.

The hypothesis testing in this study indicated a non-significant result ($p = 0.705 > 0.05$). Thus, the null hypothesis (H_0) was accepted, and the alternative hypothesis (H_1) was rejected, meaning that the PBL model integrated with Mind Mapping did not affect the learning motivation of Grade X students at MA Miftahul Ulum Bettet Pamekasan. This finding is based on the independent-samples t-test, which indicates that differences in motivation scores between the experimental and control groups were not statistically significant.

This result is inconsistent with earlier research reporting that implementing PBL integrated with Mind Mapping increases learners' learning motivation (Firdaus et al., 2022). PBL integrated with Mind Mapping can increase motivation and mastery of learning concepts (Izzah & Sukmawati, 2022). Sumarji (2009) also reported that PBL can enhance motivation and problem-solving ability. Previous studies may have found increased motivation because PBL was used as a treatment compared with conventional instruction. In the present study, however, the experimental

class used PBL while the control class used a scientific approach; in general, both methods are known to improve students' learning motivation.

PBL allows students greater freedom to learn problem-solving and to search for solutions based on their abilities, in collaboration with peers who may have similar learning styles. The implementation of differentiated instruction through the Problem-Based Learning model has been shown to encourage students to be more active in the learning process; additionally, this approach helps learners understand their learning preferences, making them feel more comfortable during learning (Annisa et al., 2025). To support the achievement of instructional goals in accordance with student characteristics, Mind Mapping is also appropriate. This model (a) provides a clear overall picture, (b) enables learners to see details without losing connections across topics, (c) presents information in structured clusters, (d) captures visual attention so it is not boring, (e) helps concentration, and (f) is enjoyable to create because it involves pictures, colors, and other visual elements (Sitanggang, 2025).

Mind Mapping can serve as an alternative solution for educators who find it difficult to develop and deliver instructional materials in online learning. In addition to being easy to create, Mind Mapping is attractive to learners and may increase students' enthusiasm and motivation to learn. Furthermore, using Mind Mapping as a learning medium is expected to be consistent with prior studies indicating that mind-mapping-based media improve learners' understanding of content. Mind maps may also increase motivation and interest among learners during learning activities, as instruction using Mind Mapping can offer sufficient flexibility to maintain interest while facilitating curiosity and keeping learners' motivation on track (Narsan, 2022).

Learning motivation fundamentally arises from within the learner, but it can be strengthened through external factors, one of which is the use of the Problem-Based Learning (PBL) model. In the learning process, teachers can enhance student motivation by providing fair assessments, offering praise or positive responses, fostering a comfortable learning atmosphere, and clearly communicating learning objectives. Hence, students understand the importance of the material. Analysis indicates that implementing PBL can increase students' participation and cognitive learning outcomes by providing opportunities for active engagement, such as collecting and processing data and solving problems, which leads to deeper understanding. Thus, PBL can support learning motivation and encourage positive behavioral change in teaching and learning through directed interaction among teachers, students, and their environment (Azizi & Irwansah, 2020).

Although this study found no effect of PBL integrated with Mind Mapping on students' learning motivation, the results showed that the mean motivation score in the experimental class (PBL + Mind Mapping) was 71.2, slightly lower than the control class score of 72.3 (Table 2). This may have occurred because students did not complete the motivation questionnaire seriously, so the data obtained did not reflect their actual motivation. This phenomenon is consistent with Calderon Vriesema and Gehlbach (2021), who reported that low motivation when responding to surveys (survey satisficing) can reduce data validity. However, its impact on overall data may vary.

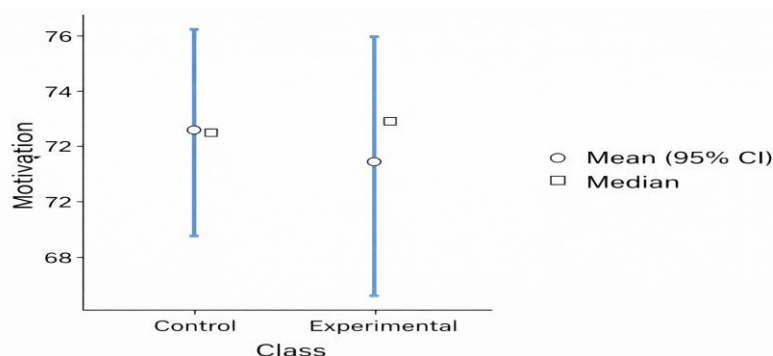


Figure 1. Mean student motivation scores

On the other hand, a recent meta-analysis by Wijnia et al. (2024) concluded that the effect of PBL on student motivation is generally small or trivial. In this study, a key factor influencing the findings was the limited number of face-to-face sessions during instruction. The researcher had limited time to implement PBL integrated with Mind Mapping, namely, three face-to-face meetings. Ideally, the PBL syntax requires sufficient time and stages to achieve optimal results, particularly in building motivation gradually and deeply. Data collection took place across three sessions for the experimental class and two sessions for the control class. In the experimental class, the teacher implemented PBL integrated with Mind Mapping. The lesson began with observing authentic water pollution problems, followed by group discussion, investigation, solution development, and the creation of a mind map to visualize concepts. These activities demanded active engagement, including critical thinking, collaboration, and presentation through Mind Mapping.

Meanwhile, the control class received instruction through lectures. The teacher delivered the material directly, and students took notes and listened to the explanation. Interaction was largely one-way, but the instructional structure was simpler and more familiar to students. Although the five phases of the PBL syntax were implemented well and student participation was evident, the motivation questionnaire results did not show a significant difference compared with the control group. This suggests that the successful implementation of PBL syntax did not fully translate into a measurable increase in motivation. One identified reason was the researcher's lack of emphasis on the importance of completing the learning motivation questionnaire, leading students to fill it out without fully understanding its role in evaluating the learning process.

Conclusion

Based on the research results, the t-test for the learning motivation variable showed $p > 0.05$. This indicates that there was no statistically significant difference in mean learning motivation between the experimental and control classes. Therefore, the Problem-Based Learning (PBL) model integrated with Mind Mapping did not demonstrate a significant effect on students' learning motivation.

Recommendation

Biology teachers are encouraged to integrate the PBL model more broadly in the learning process, particularly for topics that require deep conceptual understanding. PBL can be a strategic alternative for increasing student activeness and critical thinking skills. Future researchers are advised to broaden the scope of this study to other educational levels and subjects and to examine more deeply the effectiveness of PBL in developing 21st-century skills such as collaboration, communication, and creativity.

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References

- Adawiyah, R., Irawan, F., Zubaidah, S., & Arsih, F. (2023, January). The relationship between creative thinking skills and learning motivation in improving student learning outcomes. In *AIP Conference Proceedings* (Vol. 2569, No. 1, Article 020019). AIP Publishing LLC.

- Agrifina, V. F., Vrisilia, V., Agustina, L. N., Supriyadi, S., & Izzatika, A. (2024). Pentingnya motivasi belajar dalam meningkatkan hasil belajar siswa di sekolah dasar. *PEDAGOGIKA: Jurnal Pedagogik dan Dinamika Pendidikan*, 12(2), 414–431. <https://doi.org/10.30598/pedagogikavol12issue2page414-431>
- Alford, S., & Teater, B. (2025). Quantitative research. In *Handbook of research methods in social work* (pp. 156–171). Edward Elgar Publishing.
- Alifah. (2021). Peningkatan kualitas pendidikan di Indonesia untuk mengejar ketertinggalan dari negara lain: Education in Indonesia and abroad, advantages and lacks. *CERMIN: Jurnal Penelitian*, 5(1), 113–122. https://unars.ac.id/ojs/index.php/cermin_unars/article/view/968
- Amirudin, A., Muzaki, I. A., & Nurhayati, S. (2025). Problem-based learning as a pedagogical innovation for transforming higher education students' Islamic religious comprehension. *Educational Process: International Journal*, 18, e2025412.
- Asmaliyah, F., Keriyani, N. M. I., & Nugroho, S. (2025). Meningkatkan motivasi dan hasil belajar peserta didik melalui penerapan model problem based learning dengan pendekatan culturally responsive teaching dalam pembelajaran matematika. *Jurnal Ilmiah Profesi Pendidikan*, 10(1), 840–850.
- Azizi, A., & Irwansah, I. (2020). Pengaruh penggunaan model PBL terhadap motivasi belajar biologi siswa kelas X MIA. *Jurnal Ilmiah Global Education*, 1(2), 186–192. <https://doi.org/10.55681/jige.v1i2.52>
- Caldwell, A. R. (2022). SimplyAgree: An R package and jamovi module for simplifying agreement and reliability analyses. *Journal of Open Source Software*, 7(71), 4148.
- Cong, L., & Ironsi, C. S. (2025). Integrating mobile learning and problem-based learning in improving students' action competence in problem-solving and critical thinking skills. *Humanities and Social Sciences Communications*, 12(1), 1–11.
- Croasmun, J. T., & Ostrom, L. (2011). Using Likert-type scales in the social sciences. *Journal of Adult Education*, 40(1), 19–22.
- de Souza, R. S., Sequeira, C. A., & Borges, E. M. (2024). Enhancing statistical education in chemistry and STEAM using JAMOVI. Part 1: Descriptive statistics and comparing independent groups. *Journal of Chemical Education*, 101(11), 5027–5039. <https://doi.org/10.1021/acs.jchemed.4c00563>
- Djarwo, C. F. (2020). Analisis faktor internal dan eksternal terhadap motivasi belajar kimia siswa SMA Kota Jayapura. *Jurnal Ilmiah IKIP Mataram*, 7(1), 1–7. <https://e-journal.undikma.ac.id/index.php/jiim/article/view/2790/1969>
- Dwie Annisa, Nanda Saridewi, & Rizqy Nur Solihat. (2025). Pengaruh pembelajaran berdiferensiasi terhadap motivasi belajar dan hasil belajar siswa pada materi larutan penyangga. *Journal of Chemistry Sciences and Education*, 2(1), 21–28. <https://doi.org/10.69606/jcse.v2i01.240>
- Farizal Firdaus, Marmi, Dina Chamidah, & Sunaryo. (2022). Pengaruh model pembelajaran problem based learning terintegrasi mind mapping terhadap motivasi dan hasil belajar siswa. *Journal of Natural Sciences and Learning*, 1(1), 8–11. <https://doi.org/10.30742/jnsl.v1i1.17>
- Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 10(2), 486–489. <https://doi.org/10.5812/ijem.3505>
- Hendryadi, H. (2017). Validitas isi: Tahap awal pengembangan kuesioner. *Jurnal Riset Manajemen dan Bisnis*, 2(2), 259–334.

- Izzah, S. I. N., & Sukmawati, W. (2022). Pengaruh model problem based learning terhadap motivasi belajar peserta didik pada pembelajaran IPS. *Ideas: Jurnal Pendidikan, Sosial, dan Budaya*, 8(3), 765. <https://doi.org/10.32884/ideas.v8i3.852>
- Karnila Widiastuti, K., & Fitrotun Nisa, A. (2024). Pengaruh metode PBL berbasis mind mapping terhadap hasil belajar IPA siswa kelas VI SDN 1 Setrojenar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 9, 2104–2113.
- Khadijah, I., Nurhadi, M. W. J., Wijaya, A., Baiturrahman, R., Azahra, K. Z. F., & Hambali, M. S. (2025). Pengaruh problem based learning terhadap kemampuan memecahkan masalah peserta didik. *Jurnal Pendidikan Indonesia: Teori, Penelitian, dan Inovasi*, 5(4).
- Krishnan, P. (2025). A review of the non-equivalent control group post-test-only design. *Nurse Researcher*, 33(2).
- Kurniawati, F. N. A. (2022). Meninjau permasalahan rendahnya kualitas pendidikan di Indonesia dan solusi. *Academy of Education Journal*, 13(1), 1–13. <https://doi.org/10.47200/aoej.v13i1.765>
- Lonita, F., & Simatupang, H. (2020). Pengaruh model problem based learning terhadap kemampuan pemecahan masalah materi pencemaran lingkungan siswa SMA Negeri 13 Medan. *Jurnal Biolokus*, 3(1), 245–251.
- Lu, L., Mustakim, S. S., & Muhamad, M. M. (2025). A meta-analysis of the effectiveness of problem-based learning on critical thinking. *European Journal of Educational Research*, 14(3), 789–804.
- Muñoz Alvarez, G., Greca, I. M., & Arriasecq, I. (2025). Problem-based learning as a strategy for teaching physics in technical–professional higher education: A case study in Chile. *Education Sciences*, 15(8), 941.
- Mulyani, N., Tanti, T., & Murni, P. (2025). The effect of problem-based learning on students’ conceptual understanding reviewed from students’ beliefs. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 10(2), 208–216.
- Nafisah, M., Mu’tafi, A., & Munawaroh, H. (2025). Implementasi model problem based learning (PBL) dalam menumbuhkan semangat belajar siswa kelas X pada pembelajaran akidah akhlak di MA Takhassus Al-Qur’an 1 Mojotengah. *Journal Sains Student Research*, 3(4), 736–746.
- Narsan, V. O. (2022). Penggunaan media pembelajaran mind mapping terhadap motivasi belajar mahasiswa pada mata kuliah genetika selama pembelajaran daring. *Al Jahiz: Journal of Biology Education Research*, 3(1), 9. <https://doi.org/10.32332/al-jahiz.v3i1.4874>
- Rosas, L. G., Chen, S., Xiao, L., Baiocchi, M., Ng, E., Emmert-Aronson, B. O., ... & Tester, J. (2025). The effectiveness of Recipe4Health: A quasi-experimental evaluation. *American Journal of Preventive Medicine*, 68(2), 377–390.
- Siswanto, E., Rahayu, W., & Meiliasari, M. (2025). Optimalisasi kemampuan pemecahan masalah matematika melalui implementasi pembelajaran problem based learning (PBL): Systematic literature review. *SJME (Supremum Journal of Mathematics Education)*, 9(1), 181–195.
- Sitanggang, C. S. S. (2025). Pengaruh model pembelajaran problem based learning berbasis mind mapping terhadap kemampuan berpikir kritis mata pelajaran IPAS siswa kelas IV SDN 068007 Simalingkar tahun 2024/2025. *Quaerite Veritatem: Jurnal Pendidikan*, 4(2), 148–161. <https://doi.org/10.53842/qvj.v4i2.68>
- Šliogerienė, J., Darginavičienė, I., Suchanova, J., Gulbinskienė, D., & Jakučionytė, V. (2025). Problem-based learning in developing students’ communicative skills and creativity in teaching English for specific purposes. *Creativity Studies*, 18(1), 30–42.
- Tanujaya, B., Prahmana, R. C. I., & Mumu, J. (2022). Likert scale in social sciences research: Problems and difficulties. *FWU Journal of Social Sciences*, 16(4), 89–101.

- Vrbin, C. M. (2022). Parametric or nonparametric statistical tests: Considerations when choosing the most appropriate option for your data. *Cytopathology*, 33(6), 663–667.
- Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M. J. P., & Loyens, S. M. M. (2024). The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis. *Educational Psychology Review*, 36(1). <https://doi.org/10.1007/s10648-024-09864-3>