Vol. 14, No. 02, pp. 1059-1070, 2024 DOI: 10.23960/jpp.v14.i2.202477

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jurnal.fkip.unila.ac.id/index.php/jpp/

Implementation of Integrated Problem-Based Learning and Storytelling Technique on Learning Outcomes and Attitudes Towards Chemistry

Yunita Arian Sani Anwar*, Syarifa Wahidah Al Idrus, & Eka Junaidi
Departement of Chemistry Education, Universitas Mataram, Indonesia

*Corresponding email: yunita@unram.ac.id

Received: 09 July 2024 *Accepted: 07 August 2024* *Published: 15 August 2024*

Abstract: Implementation of Integrated Problem-Based Learning and Storytelling Technique on Learning Outcomes and Attitudes Towards Chemistry. Objective: This study aims to analyze the effect of problem-based learning (PBL) integrated with storytelling on learning outcomes and attitudes towards chemistry in basic chemistry courses. **Methods:** This experimental study employed a pretest-post-test control group design. The sample consisted of 99 new students from the Faculty of Agricultural Technology enrolled in basic chemistry courses, with 49 students in the experimental group and 50 in the control group. The research instruments included a critical thinking test with 15 validated multiple-choice questions (Cronbach's alpha = 0.817) and an attitude towards chemistry instrument based on four categories (Cronbach's alpha = 0.765). Data analysis was performed using MANOVA. **Results:** The results showed that the N-gain of student learning outcomes was higher in the experimental group compared to the control group. Similarly, students' attitudes towards chemistry in the experimental group, which received PBL with storytelling integration, were higher in all categories than those in the control group. The highest attitude scores in the experimental group were in the categories of attitude towards chemistry material and confidence in learning chemistry, while the lowest score was in the category of attitude towards chemistry laboratory work. In the control group, the highest score was in the category of the tendency to learn chemistry, with the lowest score matching the experimental group's lowest category. The MANOVA test indicated a significant effect of PBL with storytelling integration on both learning outcomes and attitudes towards chemistry. **Conclusion:** Implementing problem-based learning integrated with storytelling in basic chemistry courses positively influences learning outcomes and attitudes towards chemistry, with the experimental group showing better results compared to the control group.

Keywords: attitudes towards chemistry, critical thinking, storytelling, problem based learning.

To cite this article:

Anwar, Y. A. S., Idrus, S. W. A., & Junaidi, E. (2024). Implementation of Integrated Problem-Based Learning and Storytelling Technique on Learning Outcomes and Attitudes Towards Chemistry. *Jurnal Pendidikan Progresif*, *14*(2), 1059-1070. doi: 10.23960/jpp.v14.i2.202477.

INTRODUCTION

Learning challenges continue to concern educators at both basic and higher education levels. The critical role of science in the advancement of technology and resource management is undeniable. Science is considered an essential tool to address global issues (Jeffries et al., 2020). Ensuring that future generations are interested in and proficient in science remains a priority in developing human resources capable of solving global problems through scientific approaches (Bautista et al., 2022).

The preparation of quality human resources in science is closely tied to the educational process. Reports indicate a yearly decline in interest in science majors at both high school and college levels, attributed to various factors. A summary of these factors includes: (1) science subjects such as physics, chemistry, biology, and mathematics are not popular at the school level; (2) lack of trained science teachers; (3) low parental interest in enrolling their children in science courses; (4) poor science scores among students; (5) inadequate quality of available science books; (6) insufficient promotion of science faculty prospects to the community; (7) science subjects are perceived as requiring extensive memorization; and (8) other individual and institutional factors, such as perceptions and lack of facilities in higher education (Khan et al., 2023). Additionally, the low interest in learning science is also attributed to the lack of community programs that apply science to solve real-life problems (Klinger & Talanquer, 2022).

Chemistry, as a part of science, faces similar challenges. Each year, the number of students majoring in chemistry decreases in universities due to negative perceptions about the relevance of chemistry to future careers (Glenn & Odeleye, 2024). It is common for students to switch majors after one year of studying chemistry due to insufficient initial knowledge, which hinders their understanding of college-level content (Dong et al., 2020).

Some college majors require chemistry as a prerequisite for advanced courses. Despite being a minor subject in high school, chemistry is crucial at the college level. To produce high-quality science graduates, teaching chemistry effectively is essential. Continuous curriculum improvements in chemistry aim to prioritize critical thinking and problem-solving skills over memorization (Sanchez-Ruiz et al., 2022).

The chemistry curriculum and other science subjects are being updated to meet contemporary needs. Innovative models such as problem-based learning (PBL) are recommended to enhance thinking skills and long-term competencies. Through PBL, teachers can also enhance their professional knowledge, learning engagement, and reflective abilities in classroom instruction (Wang, 2021).

The use of Problem-Based Learning (PBL) in higher education faces several obstacles, particularly in increasing students' interest in learning. The challenges of implementing PBL are related to its impact on student engagement and the extended time required for its execution (Mohammed et al., 2024). These factors can affect learning outcomes and the achievement of learning indicators (Hsu & Rowland-Goldsmith, 2021).

In the Faculty of Animal Science, chemistry courses are mandatory prerequisites for other courses. Initial investigations reveal that students come from diverse high school backgrounds, possess different learning styles, and have varying levels of initial knowledge in chemistry. Student perceptions of chemistry also vary significantly: 13% of students come from non-science majors, 68% prefer learning through engaging media such as videos and discussions, and 76% find chemistry difficult to understand. These initial observations are crucial in determining an appropriate learning model.

For the past three years, the PBL model has been implemented in chemistry learning in higher education. The initial stage of PBL, which involves defining questions or problem orientation, is critical for the success of subsequent learning stages (Almulhem & Almulhem, 2022). This stage presents a challenge for lecturers, who must make chemistry concepts interesting and maintain student engagement throughout the learning process. Lecturers need strategies to stimulate student interest as part of the initial PBL syntax. Early engagement can boost students' enthusiasm to solve problems, thereby achieving learning indicators (Lim, 2023).

The use of storytelling techniques in science learning is uncommon among teachers, as it is often considered contrary to the scientific process.

Teachers tend to prefer serious methods such as inquiry, discovery, experimentation, or hands-on learning (Olson, 2015). While these methods can be successful in science education, many students feel less engaged because the learning process is dominated by the teacher's explanation of concepts (Maharaj-Sharma, 2022).

In the context of chemistry learning, a literature review by Arya and Maul (2012) highlighted the use of storytelling through the story of Marie Curie's discovery of radium. However, the use of storytelling for concept visualization, which can aid students' imagination, has not yet been extensively reported. Imagination is crucial in the learning process as it helps students understand the cause and effect of the concepts taught, thereby enhancing their absorption and recall abilities (Browning & Hohenstein, 2015).

Storytelling is an ancient learning strategy used to describe events in an engaging manner across all age groups. The delivery of storytelling can evolve over time (Condy et al., 2012). Although not commonly used in chemistry learning, storytelling has been shown to promote argumentation skills in physics and mathematics (Boscolo et al., 2024). This method, while rare, can be applied to all subjects, as the integration of content and narrative aids student understanding (Ran et al., 2020).

The integration of storytelling in PBL has not yet been reported in the context of chemistry learning. Given the stages of PBL and the suitability of storytelling, integration should focus on the initial stage of PBL syntax to stimulate students in formulating questions. According to Boscolo et al. (2024), storytelling can increase listeners' curiosity, providing a good stimulus for learning.

Stimulus is an important aspect that teachers must master in the learning process. Providing stimulus can significantly impact the expected outcomes, leading to a better understanding of concepts and improved learning results. Teachers need to maximize the factors that influence these outcomes to enhance the learning process effectively. One factor that still needs development in chemistry education is students' attitudes toward the subject. Attitude is considered a critical element that can influence students' learning skills. Studies show that students with positive attitudes toward chemistry are more likely to develop skills such as responsibility and initiative. This is because a positive attitude towards chemistry is associated with students' intrinsic motivation to achieve the ultimate goals of the learning process (Hofstein & Mamlok-Naaman, 2011). Yunus & Al (2018) found that interest influences success in applying chemistry learning skills. Additionally, interest in studying chemistry can affect learning achievement in both cognitive and psychomotor domains, such as conducting experiments and compiling scientific reports (Touroutoglou et al., 2015).

This research aims to analyze the application of PBL with storytelling integration in chemistry learning. The research questions are:

1. How are students' chemistry learning outcomes affected by the application of PBL with storytelling integration?
2. How do students' attitudes toward chemistry change after the application of PBL with storytelling integration?
3. How does PBL with storytelling integration influence students' learning outcomes and attitudes toward chemistry?

METHOD

Participants

This study sampled new students from the Faculty of Agricultural Technology who were required to take basic chemistry courses. The study population comprised 153 students. From this population, a total sample of 99 students was selected: 49 students in the experimental class and 50 students in the control class. The demographics of the research sample are presented in Table 1.

Tabel 1. Demographics of the research sample

	Control	Experiment
Gender		
Male	8	9
Female	41	41
Age		
18 yo	5	7
19 yo	44	43

Research Design and Procedures

This study employed an experimental research design with a pretest-posttest control group format (Creswell, 2009). Group selection was randomized, and a pretest was conducted to assess the initial abilities of both groups. The control group utilized the problem-based learning (PBL) model without the integration of the storytelling method, while the experimental group used the PBL model combined with the storytelling method (Sugiyono, 2015).

The problem-based learning (PBL) model used in this study consists of five learning phases: problem demonstration, problem analysis, problem exploration, problem solving, and problem evaluation (Chang & Hsu, 2016). The lecture materials covered chemical changes, atomic structure, and molecular structure.

In the experimental class, the stories used were titled "Me and My Best Friend," representing the concept of chemical changes; "I'm a Strong Little One," representing the concept of atomic structure; and "Four-Handed Carbon," representing the material of molecular structure. These stories were developed from various online sources. The learning scenarios for both the control and experimental classes are shown in Table 2.

Table 2. Learning scenarios

PBL Step	Experimental Group	Control Group
Problem Demonstration	1. Students are introduced to the problem through a brief explanation related to the topic of the material 2. Lecturers explain the material topics and problems to be solved using the lecture method	1. Students are introduced to the problem through a brief explanation related to the topic of the material. 2. Lecturers explain the material topics and problems to be solved using the lecture method
Problem Analysis	1. Lecturer divides students into several groups with 4-5 members per group. 2. Students in groups analyze the problems given by the lecturer based on the stories presented.	1. Lecturer divides students into several groups with 4-5 members per group. 2. Students in groups analyze the problems given by the lecturer based on the teaching material provided.
Problem Exploration	1. Students in groups explore the problem by finding information from various sources. 2. Lecturers act as facilitators in helping students study problems from story sources and available reading sources.	1. Students in groups explore problems by finding information from various sources. 2. Lecturers act as facilitators in helping students examine problems from available reading sources.
Problem Solving	1. Students discuss with group mates in solving the problems given	1. Students discuss with group mates in solving the problems given

	2. The lecturer acts as a facilitator of the problem solving chosen by each group.	2. Lecturers act as facilitators of problem solving chosen by each group.
Problem Evaluation	1. Students report the results of the discussion. 2. Lecturers provide feedback on the results of student discussions.	1. Students report the results of the discussion. 2. Lecturers provide feedback on the results of student discussions.

Students in both groups were given a pre-test to determine their initial abilities. After the treatment, students were given a post-test and the attitude towards chemistry instrument. Additionally, the experimental class was asked to submit free responses related to their learning experience.

Research Instruments

This study utilized two types of research instruments: one to measure learning outcomes and another to assess attitudes towards chemistry. Learning outcomes were measured using critical thinking questions aligned with specific material indicators. A total of 15 reasoned multiple-choice questions, validated and with a reliability value (Cronbach's alpha) of 0.817, were used, making the instrument suitable as a measurement tool. The attitude towards chemistry instrument was developed based on four selected categories, each containing three positive and three negative statements (Table 3). Each statement had five answer choices: strongly agree, agree, doubt, disagree, and strongly disagree. The instrument was tested and found to have a Cronbach's alpha value of 0.765.

Table 3. Attitude towards chemistry categories

No	Category	Statement
1.	liking for chemistry theory lessons	a. I like chemistry more than any other subject b. Chemistry is an uninteresting subject. c. Chemistry is my favorite subject
2.	liking chemistry laboratory work	a. I dislike chemistry laboratory work b. When I carry out investigations in the laboratory, I feel I am doing something important c. Laboratory work is a fun activity
3.	evaluate beliefs about school chemistry	a. Chemistry is not needed in life b. People should understand chemistry because it can affect life c. Chemistry is one of the most important subjects to learn
4.	behavioral tendencies to learn chemistry	a. I don't like spending time reading chemistry books b. I enjoy solving chemistry problems c. If I had the chance, I would complete a chemistry project

Data Analysis Technique

Pre-test and post-test data were collected and tabulated, and the average scores were calculated. The scores were then statistically analyzed for differences using SPSS 21. The impact of using stories on learning outcomes and attitudes towards chemistry was analyzed using MANOVA. Free response data was coded and described to understand student responses to the use of stories in learning chemistry.

RESULT AND DISCUSSION

The final learning outcomes of students in both treatment groups showed significant differences compared to the initial learning outcomes. The average pre-test scores of the control and experimental classes were 62.12 and 61.84, respectively. Analysis of the pre-test results for both groups showed no significant difference before receiving the PBL ($p > 0.05$) treatment integrated with storytelling.

Research Question 1: After the treatment, the group using storytelling showed higher mean learning outcomes than the control group. The average N-gain results also indicated higher values for the storytelling group compared to the control group (Figure 1).

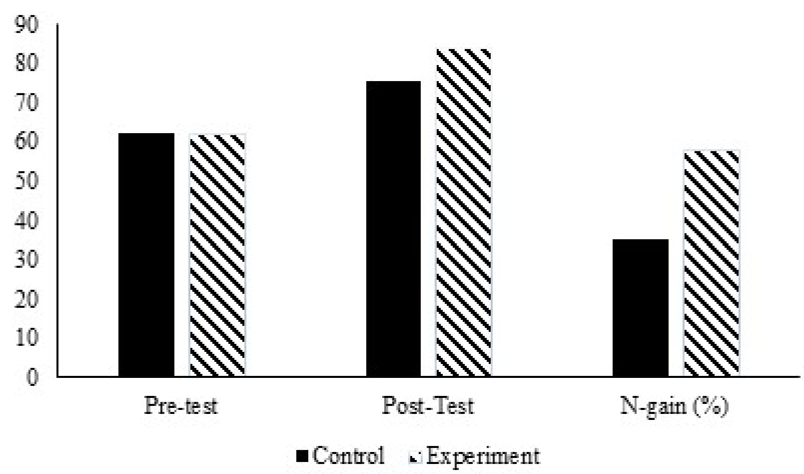

Figure 1. Learning outcome score control and experiment group

The use of storytelling in PBL creates a different atmosphere for learning chemistry. Typically, chemistry learning is associated with unfamiliar terms and serious narratives. Storytelling introduces characters and conflicts, making the learning process more engaging and providing a real visualization for students (Ran et al., 2020).

In the first discussion about chemical changes, students were presented with the story "Me and My Best Friend," which described chemical and physical changes. The story's conflict helped students easily remember the characteristics of these changes and find everyday examples. Pre-test results showed that many students previously could not distinguish between physical and chemical changes, a difficulty also reported in earlier studies (Kariper, 2014). This challenge may stem from inappropriate teaching strategies, difficult-to-understand narratives, and a lack of connection to real-world events (Timilsena et al., 2022).

Student activity increased with each story presented. In the story "Carbon with Four Hands," students easily grasped the concept of carbon bonds through the "hands" illustration. Previously, students struggled with understanding chemical bonds, even those who had covered the material in high school. Storytelling significantly improved their ability to describe Lewis structures and compound molecules. In contrast, the control class made many errors, particularly in describing chemical bonds between carbon atoms and other atoms.

Chemistry's complexity poses significant challenges for science students. Basic concepts such as reaction mechanisms, stoichiometry, enthalpy, and chemical bonding are notably difficult (Kyado et al., 2021). More than 70% of students reported difficulties understanding factual information, chemical equations, and mathematical aspects of chemistry. These challenges are often due to complex mathematical concepts difficult narratives (Ullah et al., 2022).

Learning activities in the control class appeared challenging from the start of PBL. Students struggled to understand the problems presented. In contrast, the experimental class found it easier to grasp problems integrated with story conflicts. Storytelling provided a learning environment conducive to visualizing concepts more clearly. According to Oliveira et al. (2019), stories enable listeners to imagine and better understand introduced concepts, enhancing student comprehension (Ullah et al., 2022).

Research Question 2: The attitude towards chemistry analysis revealed that the experimental group scored higher than the control group in all attitude categories. The highest attitude category in the experimental group was liking for chemistry theory lessons (LCTL) (X = 3.85, SD = 0.322) and evaluate beliefs about school chemistry (EBSC) (X = 3.85, SD = 0.334), while the lowest category was liking chemistry laboratory work (LCLW) (X = 3.12, SD = 0.526). In contrast, the highest category in the control group was behavioral tendencies to learn chemistry (X = 3.07, SD = 0.391), and the lowest category was the same as the experimental group (X = 2.32, SD = 0.451). The average of each category in both groups is shown in Figure 2.

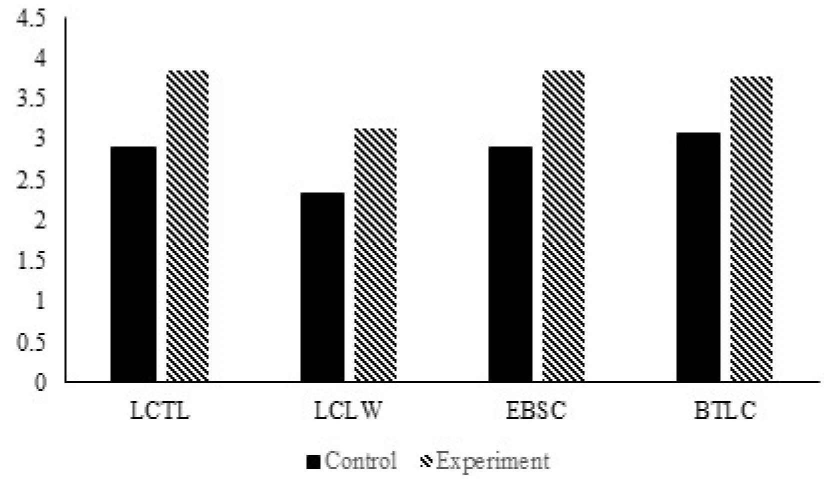

Figure 2. Attitude towards chemistry score control and experiment group

Aligned with learning outcomes, the experimental class showed higher attitude scores towards chemistry compared to the control class. This suggests that storytelling integration positively impacts chemistry learning. In the control class, liking for chemical concepts was lower than in the experimental class. Positive attitudes towards chemistry in the experimental class contributed to higher N-gain in student learning outcomes.

Several studies have reported the positive contribution of attitudes towards chemistry to student learning outcomes. A positive attitude can motivate students to study chemistry more deeply (Keen & Sevian, 2022). Interesting teaching methods can help students overcome difficulties in learning chemistry (Al-Najdi, 2013).

Research Question 3: The effect of storytelling integration in PBL on learning outcomes and attitudes towards chemistry was tested using MANOVA. The Box test showed a significance level of 0.434, indicating that the variances of learning outcomes and attitudes towards chemistry were the same, fulfilling the assumptions of MANOVA. The F-test value for the relationship between the treatment and the variables of learning outcomes and attitudes towards chemistry was 27.009 and 200.990, respectively ($p < 0.05$), indicating a significant relationship between PBL integrated storytelling and learning outcomes and attitudes towards chemistry. MANOVA analysis is shown in Table 4.

Tabel 4. MANOVA analysis

Source	Dependent Variable	Type III Sum of Square	Df	Mean Square	F	Sig.
Corrected Model	Learning Outcome	12514.766	1	12514.766	27.009	.000
	Attittude	17.989	1	17.989	200.990	.000
Intercept	Learning Outcome	214249.275	1	214249.275	462.379	.000
	Attittude	1029.055	1	1029.055	11497.326	.000
Perlakuan	Learning Outcome	12514.766	1	12514.766	27.009	.000
	Attittude	17.989	1	17.989	200.990	.000
Error	Learning Outcome	44946.190	97	463.363		
	Attittude	8.682	97	.090		
Total	Learning Outcome	270687.180	99			
	Attittude	1053.084	99			
Corrected Total	Learning Outcome	57460.956	98			
	Attittude	26.671	98			

Free response data from students in the experimental class showed a positive response to the use of PBL integrated storytelling in chemistry learning. The aspects highlighted by students were divided into five categories: the uniqueness of the method (86%), learning is more fun (83.5%), easy to understand the material (79.5%), easy to remember the material (88%), and not boring (87%) (Figure 3).

The relationship between attitudes towards chemistry and academic achievement is crucial for teachers to consider. Developing positive

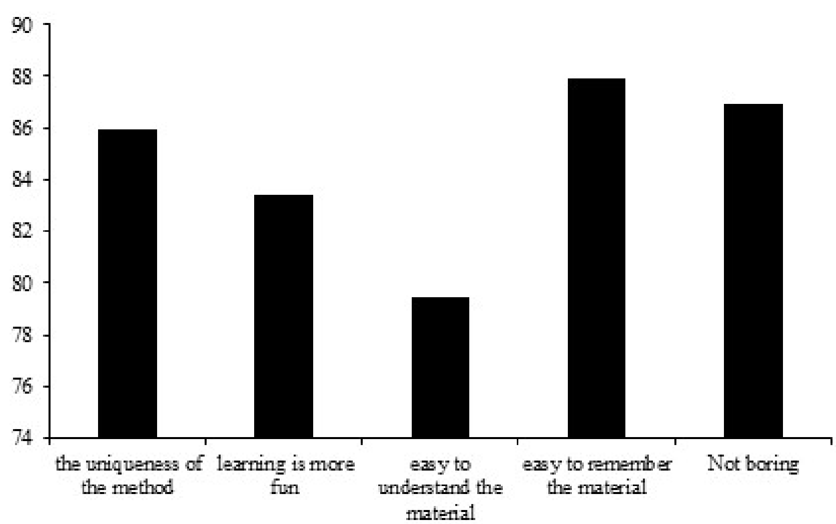

Figure 3. Free respon data analysis

attitudes can influence other affective factors such as anxiety, self-efficacy, motivation, and cognitive abilities, ultimately contributing to academic success (Thangavel & Selvan, 2024).

Student responses in the experimental class highlighted the benefits of storytelling in five aspects: the uniqueness of the method, making learning more fun, easier understanding and remembering of material, and reducing boredom. These responses relate to both cognitive and affective domains, consistent with Medupin's (2024) findings that storytelling enhances understanding and motivates students to learn. Storytelling methods can also foster higher-level thinking and literacy skills (Boscolo et al., 2024).

However, the use of storytelling also presents challenges. Teachers must develop engaging stories to stimulate student interest. The characters and conflicts must be designed to keep chemistry teaching dominant in the learning process. Time management is also a challenge, as storytelling can be time-consuming.

Previous studies have outlined challenges in using storytelling. Inappropriate narratives can lead to misconceptions. Teachers need to create logical and realistic stories, possibly depicting scientific work or linking science activities to the environment (Soares et al., 2023). Digital systems can also enhance storytelling in the learning process (Maharaj-Sharma, 2024).

■ CONCLUSION

The integration of storytelling into PBL significantly enhances learning outcomes and student attitudes towards chemistry, as evidenced by higher N-gain scores. Statistical analyses confirm a significant impact of this integrated approach on both learning outcomes and attitudes. Student feedback highlights several positive factors, including the uniqueness of the method, increased enjoyment of learning, easier understanding and retention of material, and a reduction in boredom.

The use of storytelling can be an effective method to improve students' attitudes toward learning chemistry. A positive attitude fostered by storytelling is expected to facilitate a better understanding of chemical concepts. Although currently limited to basic chemistry courses, this technique is hoped to aid visualization through imagination in other courses as well. Additionally, storytelling can inspire the creation of engaging and creative chemical content by both students and teachers. However, this research is limited by a small number of respondents and a narrow range of story titles, so further development is anticipated in the future.

■ REFERENCES

Almulhem, M.A., & Almulhem, J.A. (2022). Evaluation of problem-based learning implementation in a college of medicine, kingdom of saudi arabia: a cross-sectional comparative study. *BMC Medical Education*, 22(311), 1-12. Doi: https://doi.org/10.1186/s12909-022-03347-1

Al-Najdi, S.D. (2013). Students' attitude towards learning chemistry students' attitude towards learning chemistry. *Journal of Al-Quds Open University for Educational & Psychological Research & Studies*, 1(1), 1-17.

Arya, D. J., & Maul, A. (2012). The role of the scientific discovery narrative in middle school science education: An experimental study. *Journal of Educational Psychology*, 104(4), 1022– 1032.

Bautista, N. M., Quileza, E. S., & Rojo, M. D. (2022). Factors associated with low enrollment and performance of senior high school students in Science, Technology, Engineering, and Mathematics (STEM). *Asia Pacific Journal of Education*, 42(1), 112–22. https://doi.org/10.1080/02188791.2020.1839129

Boscolo, A., Lippiello, S., & Pierri, A. (2024).

Storytelling as a skeleton to design a learning unit: A model for teaching and learning optics. *Education Sciences*, 14(3), 218. Doi: https://doi.org/10.3390/educsci14030218

Bratitsis, T., & Ziannas, P. (2015). From early childhood to special education: Interactive digital storytelling as a coaching approach for fostering social empathy. *Procedia Computer Science*, 67, 231-240. Doi: https://doi.org/10.1016/j.procs.2015.09.267

Browning, E., & Hohenstein, J. M. (2015). The use of narrative to promote primary school children's understanding of evolution. *Education*, 13(43), 530- 547.

Condy, J., Chigona, A., Gachago, D., & Ivala, E. (2012). Pre-service students' perceptions and experiences of digital storytelling in diverse classrooms. *TOJET: The Turkish Online Journal of Educational Technology*, 11(3), 278-285.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Sage Publications, Inc.

Dong, A., Jong, M.S.Y., & King, R.B. (2020). How does prior knowledge influence learning engagement? the mediating roles of cognitive load and help-seeking. *Front. Psychol., 11*, 591203. https://doi.org/10.3389/fpsyg.2020.591203

Glenn, C.D., & Odeleye, O.O. (2024). Exploring factors within an introductory course that influence students' perception of chemistry. *Chemistry Education Research and Practice*, 25, 775-785. Doi: https://doi.org/10.1039/D4RP00008K

Hofstein, A., & Mamlok-Naaman, R. (2011). High-School students' attitudes toward and interest in learning chemistry. *Educacion Quimica*, 22(2), 90-102. Doi: 10.1016/s0187-893X(18)30121-6.

Hsu, J.L. & Rowland-Goldsmith, M. (2021). Student perceptions of an inquiry-based molecular biology lecture and lab following a mid-semester transition to online teaching. *Biochemistry Molecular Biology Education*, 49(1), 15–25. Doi: https://doi.org/10.1002/bmb.21478

Jeffries, D., Curtis, D. D., & Conner, L. N. (2020). Student factors influencing STEM subject choice in year 12: A structural equation model using PISA/LSAY data. *International Journal of Science and Mathematics Education*, 18(3), 441–461. https://doi.org/10.1007/s10763-019-09972-5

Kariper, I.A. (2014). Misconception About Between Physical and Chemical Changing of Matters of Primary School Students. *European Journal of Physics Education*, 5(2), 15-19.

Keen, C., & **Sevian**, H. (2022). Qualifying domains of student struggle in undergraduate general chemistry laboratory. *Chemistry Education Research and Practice*, 23, 12-37. Doi: https://doi.org/10.1039/D1RP00051A

Khan, S., Shiraz, M., Shah, G., & Muzamil, M. (2023). Understanding the factors contributing to low enrolment of science students in undergraduate programs. *Codent Education*, 10(2), 1-22. Doi: https://doi.org/10.1080/2331186X.2023.2277032.

Klinger, D. A., & Talanquer, V. (2022). A STEM Identity framework for supporting student success in undergraduate science. *Journal of Chemical Education*, 99(1), 46–55. https://doi.org/c10.1021/acs.jchemed.1c0014

Kyado, J., Achor, E.E., & Adah, E. (2021). Identification of difficult concepts in chemistry by some secondary school students and teachers in Nigeria. *Journal of the International Centre for Science,* *Humanities and Education Research,* 5(1), 85-98.

Lim, T. (2023). Problem-based learning: benefits, challenges, and the way forward. In: K.Heng., K.Sol., S.Kaing., & S.Em (Eds)., Innovation and Challenges in Cambodian Education: Youth's Perspectives.

Maharaj-Sharma, R. (2024). Using storytelling to teach a topic in physics. *Education Inquiry*, 15(2), 227-246. Doi: https:// doi.org /10.1080/20004508.2022. 2092977

Medupin, C. (2024). Perspectives on using storytelling as a means of teaching and learning: reflections from diverse groups of participants on the theme"what's in your river?". *Education Science*, 14, 18. https:/ / doi.org/10.3390/educsci14010018

Mohammed, A.B., Zegeye, R.T., Dawed, H.A., & Tessema, Y.M. (2024). Implementation of problem-based learning in undergraduate medical education in Ethiopia: An exploratory qualitative study. *Advances in Medical Education and Practice*, 15, 105-119. Doi: https:// doi.org/10.2147/AMEP.S443384

Oliveira, R., Rodrigues, A., Farrôpo, R., & Avó, I. (2019). How can storytelling benefit the learning of science? Geophysical Research Abstracts, 21, EGU2019-10818.

Olson, R. (2015). Houston, we have a narrative: Why science needs story. Chicago: The University of Chicago Press.

Ran, H., Shen, J., Smith, B.E., Maria, K., & Wang. C. (2020). Storytelling for Science Learning: Developing an Assessment Framework to Examine Adolescents' Multimodal Sci-Fi Narratives. Conference: International Conference of the Learning Sciences At: Nashville, TN, USA

Sánchez-Ruíz, M. J., Fernández-Balboa, J. M., & Ramírez-Montoya, M. S. (2022). Predictors of science, technology, engineering and mathematics (STEM) interest and academic achievement in Mexican high school students. *International Journal of STEM Education*, 9(1), 1–21. https://doi.org/ 10.1186/s40594-022-00332-5

Soares, S., Gonçalves, M., Jerónimo, R., & Kolinsky, R. (2023). Narrating science: Can it benefit science learning, and how? A theoretical review. *Journal of Research in Science Teaching*, 60(9), 2042-2075. Doi: https://doi.org/10.1002/tea.21851

Sugiyono. (2015). *Metode penelitian dan pengembangan (research and development/r&d): untuk bidang pendidikan, manajemen, sosial, teknik* [Research and Development (R&D) methods: for education, management, social, engineering] Bandung: Alfabeta.

Thangavel, K., & Selvan, A. (2024). The relationship between attitude towards chemistry and academic performance in undergraduate chemistry courses. *Thiagarajar College of Preceptors Edu Spectra*, 6(1), 83-88. Doi: https://doi.org/ 10.34293/eduspectra.v6i1.11.

Timilsena, N.P., Maharjan, K.B., & Devkota, K.M. (2022). Teachers' and students' experiences in chemistry learning difficulties. *Journal of Positive School Psychology, 6*(10), 2856-2867.

Touroutoglou, A., Lindquist, K. A., Dickerson, B. C., & Barrett, L. F. (2015). Intrinsic connectivity in the human brain does not reveal networks for 'basic' emotions. *Social Cognitive and Affective Neuroscience*, 10(9), 1257–1265. https:/ /doi.org/10.1093/scan/nsv013.

Ullah, S., Malik, M., & Ahmad, R. (2022). Difficulties in learning concepts of chemistry at secondary level in lahore. *Journal of Positive School Psychology*, 6(10), 4333-4344.

Wang, C-C. (2021). The process of implementing problem-based learning in a teacher education programme: an exploratory case study, *Cogent Education*, 8(1), 1996870, Doi: https://doi.org/10.1080/2331186X.2021.1996870

Yunus, F.W., & Ali, Z.M. (2018). Attitude towards learning chemistry among secondary school students in Malaysia. *Asian Journal of Behavioural Studies*, 3(9), 63-70. Doi: 10.21834/ajbes.v3i9.61.