Panthera : Jurnal Ilmiah Pendidikan Sains dan Terapan
E-ISSN 2808-246X; P-ISSN 2808-3636
Volume 6, Issue 2, April 2026; Page, 1259-1267
Email: pantherajurnal@gmail.com

ENHANCING STUDENTS' UNDERSTANDING OF HYDROCARBON NOMENCLATURE THROUGH GAME-BASED LEARNING: A PRE-EXPERIMENTAL STUDY

Rekfa Wika Amini[1]*, Arvidhea Safira Gunawan[2], Siti Shofa Assyifa'ul Qulbi Barid[3], Fauziyatul Iffah[4], & Helda Wika Amini[5]
[1,2,3,&4]Science Education Department, Faculty of Teacher and Training Education, University of Jember, Kalimantan Street Number 37, Jember, East Java 68121, Indonesia
[5]Chemical Engineering Department, Faculty of Engineering, University of Jember, Kalimantan Street Number 37, Jember, East Java 68121, Indonesia
**Email: rekfa@unej.ac.id*
Submit: 07-04-2026; Revised: 15-04-2026; Accepted: 18-04-2026; Published: 30-04-2026

ABSTRACT: The study aims to examine improvements in students' understanding of hydrocarbon nomenclature following the implementation of the Wayground game-based learning in the General Chemistry I course. A quantitative approach with a pre-experimental one-group pretest–posttest design without a control group was employed. The participants consisted of 54 students from the Science Education Study Program who received instruction using the Wayground learning media. Data were collected using pretest and posttest instruments. The result revealed a large effect size (0.87) and a large N-gain (0.083), indicating a substantial improvement in students' conceptual understanding. These findings indicate that Wayground game-based learning can enhance students' understanding of hydrocarbon nomenclature and create a more engaging, interactive, and enjoyable learning environment.

Keywords: Conceptual Understanding, Game-Based Learning, Hydrocarbon Nomenclature.

How to Cite: Amini, R. W., Gunawan, A. S., Barid, S. S. A. Q., Iffah, F., & Amini, H. W. (2026). Enhancing Students' Understanding of Hydrocarbon Nomenclature through Game-Based Learning : A Pre-Experimental Study. *Panthera : Jurnal Ilmiah Pendidikan Sains dan Terapan, 6*(2), 1259-1267. https://doi.org/10.36312/panthera.v6i2.1238

INTRODUCTION

Nomenclature is a system for naming chemical compounds established by the International Union of Pure and Applied Chemistry (IUPAC) to provide names or represent molecular structures. Mastery of organic nomenclature is a fundamental competency in learning chemistry, particularly in Biochemistry, Organic, and General Chemistry courses. In addition, the correct use of nomenclature plays an important role as a universal scientific language, enabling scientists to communicate globally (Orvis et al., 2016)

Despite its very important role, learning chemical nomenclature, particularly hydrocarbon nomenclature, is often considered difficult and boring by students (Da Silva Júnior et al., 2018). This material is abstract in nature and requires an understanding of various rules. The complexity of these rules often leads to misconceptions, low learning motivation, and weak conceptual understanding among students (Gyang, 2025). This condition poses a particular challenge for educators in designing learning that is not only oriented toward conceptual mastery but also able to increase students' interest and engagement (Karini et al., 2022; Lisdiana et al., 2025)

Along with the development of educational technology, various innovative approaches have emerged to address the problem in hydrocarbon learning, including game-based learning. Educational games have been reported to increase students' motivation, engagement, and learning outcomes, as well as to enhance problem-solving skills and conceptual understanding (Lestari et al., 2020; Lisdiana et al., 2025; Nora & Lutfi, 2022; Permata & Lutfi, 2022; Rokhim et al., 2021; Wood & Donnelly-Hermosillo, 2019). The integration of game elements into learning allows students to engage in more concrete, interactive, and enjoyable experiences, thereby reducing cognitive load when learning abstract chemistry concepts (Enawaty et al., 2025; Lutfi et al., 2023).

The use of game-based learning in chemistry instruction also offers advantages, as it combines educational elements with engaging interactive technology. This approach has the potential to make the learning process more effective than conventional methods, which tend to be lecturer-centered (Hu et al., 2022). In the context of learning hydrocarbon nomenclature, games can help students visualize compound structures, gradually understand naming rules, and train naming skills through repeated and challenging exercises (Da Silva Júnior et al., 2018).

Despite the growing body of research highlighting the potential benefits of game-based learning in chemistry education, limited attention has been paid to specific, conceptually demanding subtopics, such as hydrocarbon nomenclature. In addition, previous studies have utilized various digital games, with limited emphasis on specific platforms or media. Importantly, to the best of our knowledge, no study has specifically examined the use of Wayground as a game-based learning medium for hydrocarbon nomenclature. Therefore, this study aims to fill this gap by examining the use of Wayground game-based learning media to enhance students' understanding of hydrocarbon nomenclature in the General Chemistry I course, using a pretest-posttest design.

METHOD

This study uses a pre-experimental, one-group, pretest-posttest design without a control group. This design is used to test differences in understanding of hydrocarbon nomenclature before and after playing the Wayground game. The pre-test is used to determine students' initial understanding and to analyze weaknesses in their understanding. The posttest is used to assess the difference after playing the game on Wayground. This study follows research by Nuriska et al. (2025) with modification. The participants were 54 students from the Science Education Study Program, Faculty of Teacher Education and Education, University of Jember. All participants received the same treatment through Wayground game-based learning media, and no control group was used

The learning material used in this study was hydrocarbon nomenclature in the General Chemistry I course at the Science Education Department, Faculty of Teacher Training and Education, University of Jember. Three indicators are used: identifying the types and characteristics of hydrocarbons, determining the IUPAC names of straight-chain and branched-chain hydrocarbons, and relating hydrocarbon nomenclature to everyday contexts. The interactive learning via games used is Wayground with a material mastery mode. The students are allowed to repeat the questions until mastery is achieved. The instruments used are a pretest and a posttest.Click or tap here to enter text.

The treatment was conducted over one week in two instructional periods in the General Chemistry I course. Students were given a pretest before the treatment and a posttest after the treatment. During the treatment, Wayground was used as a game-based learning medium on the hydrocarbon topic, where students practiced naming hydrocarbon compounds through interactive games. The research data consisted of pretest and posttest scores used to analyze improvement in students' understanding of hydrocarbon nomenclature. The improvement in conceptual understanding was analyzed using the normalized gain (N-Gain), which was classified into high ($\langle g \rangle \geq 0.7$), medium ($0.3 \leq \langle g \rangle < 0.7$), and low ($\langle g \rangle < 0.3$) categories according to the criteria proposed by (Hake, 1998). Furthermore, a normality test using the Kolmogorov–Smirnov test was conducted to determine whether the data were normally distributed prior to further statistical analysis. The data were considered normally distributed if $p > 0.05$ and not normally distributed if $p < 0.05$ (Fasano & Franceschini, 1987).

The differences between pretest and posttest scores were analyzed using the Wilcoxon Signed-Rank Test. The significance of the results was determined based on the Asymp. Sig. (2-tailed) value, where $p < 0.05$ indicates a significant difference, while $p > 0.05$ indicates no significant difference(Taheri & Hesamian, 2012). To determine the magnitude of the effect of implementing the Wayground game-based learning media on students' understanding of hydrocarbon nomenclature, an effect size calculation was also conducted, which was interpreted based on Cohen's criteria, namely small effect ($r \approx 0.10$), medium effect ($r \approx 0.30$), and large effect ($r \geq 0.50$) (Cohen, 1992).

RESULT AND DISCUSSION

This study began by administering a pretest to 54 science education students at the Faculty of Teacher Training and Education, University of Jember, on the topic of hydrocarbons in the General Chemistry I course. The purpose of this pretest was to determine students' basic understanding of hydrocarbons, especially nomenclature using IUPAC formulas, and to identify the obstacles they encountered in understanding it. Based on the pretest results, learning activities were designed using Wayground, a game-based learning platform, to support students' understanding of hydrocarbon nomenclature.

There were three indicators in the questions we used: identify the types and characteristics of hydrocarbons, determine the IUPAC names of straight-chain and branched-chain hydrocarbons, and relate hydrocarbon nomenclature to everyday contexts. In this game-based learning, we use a mastery-based learning approach. Students were allowed to repeat questions until they answered correctly, supporting gradual mastery of hydrocarbon nomenclature concepts. The learning activities also incorporated time-based challenges and peer competition to increase student engagement.

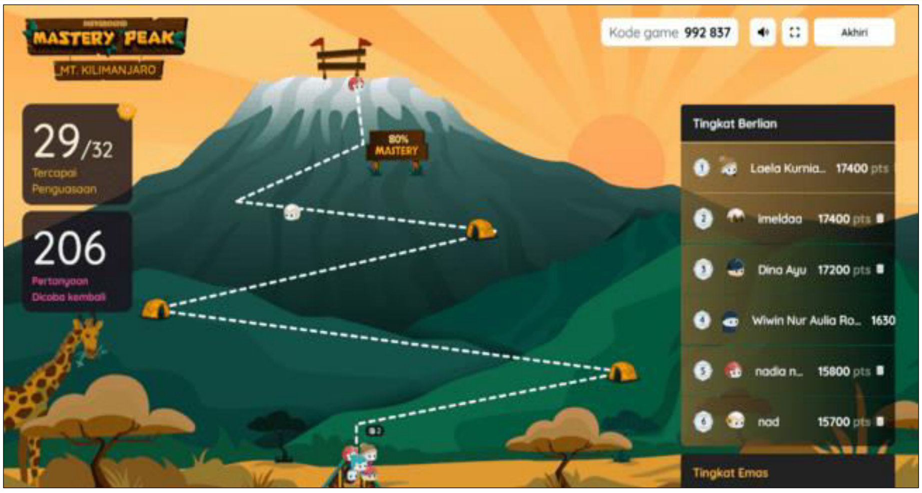

Figure 1. Real-Time Leaderboard Displaying Students' Performance During the Activity.

Figure 1 presents the real-time leaderboard displaying students' performance during the activity. Student performance was evaluated based on total completion time, response accuracy, number of attempts, and overall game performance. This design allows students to receive immediate feedback and progressively improve their understanding through repeated practice.

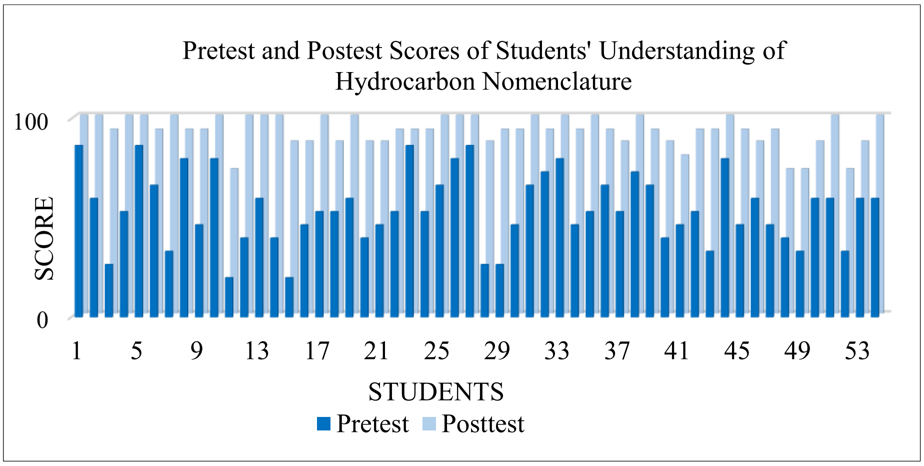

Figure 2. Pretest and *Posttest* Scores of Students' Understanding of Hydrocarbon Nomenclature.

Figure 2 shows that student scores increased before playing (pre-test) and after playing (post-test) while learning hydrocarbon material via Wayground. Posttest scores increased compared to pretest scores.

Table 1. Normality Test Result.

Test of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	0.096	54	0.200*	.966	54	.127
Post-test	0.215	54	.000	.807	54	.000

*. This is a lower bound of the true significance
a. Liliefors Significance Correction

The Kolmogorov-Smirnov test is shown in Table 1, the pretest sig. value is 0.127, which is greater than 0.05, indicating that the pretest results are normally distributed (Habibzadeh, 2023). However, the posttest results are not normally distributed with a sig. value of .000 is less than 0.050. Since the data were not normally distributed, a nonparametric test was used for further analysis. Therefore, the Wilcoxon Signed-Ranks Test was used to analyze the difference between pretest and posttest scores.

The results show a significant difference between pretest and posttest scores ($p<0.05$), indicating that students' understanding of hydrocarbon nomenclature increased after implementing the Wayground game-based learning. These findings suggest that students' understanding increased after the intervention. Similar findings were reported by Aksoy (2019), who stated that Game-Based Learning (GBL) approaches can significantly improve learning outcomes even when the data do not meet parametric assumptions.

Table 2. Wilccoxon Test Result.

		N	Mean Rank	Sum of Ranks		Posttest-pretest
Posttest-pretest	Negative Ranks	0[a]	0.00	0.00	Z	-6.405
	Positive Ranks	54[b]	27.50	1485.00	Asymp. Sig. (2-tailed)	0.000
	Ties	0[c]				
	Total	54				

a. Post-test < pre-test; b. post-test > pre-test; c. post-tets = pre-test.

The Asymp. Sig. (2-tailed) value is 0.000 ($p < 0.05$), which is less than 0.05, indicating that H0 is rejected and that there is a significant difference in the scores of science students before and after using the Wayground game-based learning (Penberthy et al., 2018). These results indicate that students' understanding of hydrocarbon nomenclature improved after implementing Wayground's game-based learning.

Table 3. The Results of Students' Understanding in Hydrocarbon Nomenclature before and After Wayground Game-Based Learning.

	Pre-test	Post-test	gain	N-gain	N-gain Criteria
Mean	54.8	92.8	37.9	0.853	High
Standard deviation	18.0	7.76	15.3	0.147	

Measurements of students' understanding of hydrocarbon nomenclature conducted before and after the implementation of Wayground, a game-based learning platform, yielded an N-gain of 0.853, in the high category, as shown in Table 3. This result indicates a substantial improvement in students' understanding based on the N-gain classification.

Table 4. Effect Size Calculation Results.

Learning Outcome	mean	Standard Deviation	Effect Size	Category
Pre-test	54.8	18.0	0.87	High
Post-test	92.8	7.76		

Table 4 shows that the average score before and after treatment increased from 54.8 ± SD 18.00 to 92.8 ± SD 7.76. The magnitude of the improvement is further supported by the effect size analysis. An effect size of 0.87, which is categorized as high, indicates that the observed improvement is practically meaningful. Previous studies have also reported that game-based learning can enhance student engagement and learning outcomes when students are actively involved in the learning process (Purcell et al., 2023). These findings suggest that the implementation of game-based learning not only improves academic performance but also fosters a more interactive and motivating learning environment.

The high N-gain (0.853) and effect size (0.87) observed in this study may be explained by several learning mechanisms embedded in the Wayground game-based learning approach. First, the mastery learning strategy allows students to repeat questions until they reach correct answers, supporting gradual conceptual understanding and reducing misconceptions. Second, immediate feedback provided during the learning process helps students identify and correct errors in real time, which is essential for learning abstract concepts such as hydrocarbon nomenclature. Third, repeated exposure to naming rules through interactive tasks may facilitate schema construction and reduce cognitive load. In addition, the use of time-based challenges and peer competition can increase student engagement and motivation, which are known to positively influence learning outcomes. These combined factors may contribute to the substantial improvement observed in students' understanding.

Overall, the findings of this study confirm and strengthen previous research indicating that game-based learning can increase student engagement, motivation, and conceptual understanding, especially in organic chemistry (Cha et al., 2018; Farmer & Schuman, 2016). These findings are consistent with prior research on game-based learning in chemistry education. The improvement may be explained by repeated practice, immediate feedback, and interactive challenges, which support conceptual understanding of abstract topics such as hydrocarbon nomenclature (Battersby et al., 2020; Byusa et al., 2022; Camarca et al., 2019; Cha et al., 2017; Clapson et al., 2020). Thus, this study provides empirical support for the use of Wayground as a game-based learning medium to enhance students' understanding of hydrocarbon nomenclature, although the findings should be interpreted with caution given the one-group research design.

CONCLUSION

Based on the results and discussion, it can be concluded that the implementation of Wayground game-based learning media is associated with an improvement in students' understanding of hydrocarbon nomenclature in the General Chemistry I course. The significant difference between pretest and posttest scores, indicated by the Wilcoxon Signed Ranks Test ($p < 0.05$), supported by a high effect size value of 0.87 and a normalized gain (N-gain) of 0.853 in the high category, indicates a substantial improvement in students' conceptual understanding. Therefore, Wayground can be considered as an alternative instructional medium in science education programs.

RECOMMENDATION

Based on the findings of this study, several suggestions can be proposed. First, lecturers are encouraged to integrate game-based learning as an alternative instructional strategy in teaching abstract chemistry topics, particularly hydrocarbon nomenclature, to enhance students' conceptual understanding, motivation, and engagement. Second, future researchers are recommended to employ more rigorous research designs, such as quasi-experimental or true experimental designs with control groups, to obtain stronger causal evidence on the effectiveness of game-based learning.

ACKNOWLEDGMENT

The authors would like to thank the students who participated in this study. This research was conducted independently without external funding.

REFERENCES

Aksoy, E. (2019). Comparing the Effects on Learning Outcomes of Tablet-Based and Virtual Reality-Based Serious Gaming Modules for Basic Life Support Training: Randomized Trial. *JMIR Serious Games, 7*(2), 1-20. https://doi.org/10.2196/13442

Battersby, G. L., Beeley, C., Baguley, D. A., Barker, H. D., Broad, H. D., Carey, N. C., Chambers, E. S., Chodaczek, D., Blackburn, R. A. R., & Williams, D. P. (2020). Go Fischer: An Introductory Organic Chemistry Card Game. *Journal of Chemical Education, 97*(8), 2226–2230. https://doi.org/10.1021/acs.jchemed.0c00504

Byusa, E., Kampire, E., & Mwesigye, A. R. (2022). Game-Based Learning Approach on Students' Motivation and Understanding of Chemistry Concepts: A Systematic Review of Literature. *Heliyon, 8*(5), 1-20. https://doi.org/10.1016/j.heliyon.2022.e09541

Camarca, M., Heuett, W., & Jaber, D. (2019). CHEMCompete-II: An Organic Chemistry Card Game to Differentiate between Substitution and Elimination Reactions of Alcohols. *Journal of Chemical Education, 96*(11), 2535–2539. https://doi.org/10.1021/acs.jchemed.9b00486

Cha, J., Kan, S. Y., & Chia, P. W. (2018). Spot the Differences Game: An Interactive Method that Engage Students in Organic Chemistry Learning. *Journal of the Korean Chemical Society, 62*(2), 159–165. https://doi.org/10.5012/jkcs.2018.62.2.159

Cha, J., Kan, S.-Y., Wahab, N. H. A., Aziz, A. N., & Chia, P. W. (2017). Incorporation of Brainteaser Game in Basic Organic Chemistry Course to Enhance Students' Attitude and Academic Achievement. *Journal of the Korean Chemical Society, 61*(4), 218–222. https://doi.org/10.5012/jkcs.2017.61.4.218

Clapson, M. L., Gilbert, B. C. T., & Musgrove, A. (2020). Race to the Reactor and Other Chemistry Games: Game-Based and Experiential Learning Experiences in Materials and Polymer Chemistry. *Journal of Chemical Education, 97*(12), 4391–4399. https://doi.org/10.1021/acs.jchemed.0c01135

Panthera : Jurnal Ilmiah Pendidikan Sains dan Terapan
E-ISSN 2808-246X; P-ISSN 2808-3636
Volume 6, Issue 2, April 2026; Page, 1259-1267
Email: pantherajurnal@gmail.com

Cohen, J. (1992). A Power Primer. *Psychological Bulletin, 112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Da Silva Júnior, J. N., Nobre, D. J., Do Nascimento, R. S., Torres, G. S., Leite, A. J. M., Monteiro, A. J., Alexandre, F. S. O., Rodríguez, M. T., & Rojo, M. J. (2018b). Interactive Computer Game that Engages Students in Reviewing Organic Compound Nomenclature. *Journal of Chemical Education, 95*(5), 899–902. https://doi.org/10.1021/acs.jchemed.7b00793

Enawaty, E., Lestari, I., Nadila, Faridy, F. A., & Ichsan, R. F. (2025). Development of Digital Literacy Based Game Cards on Hydrocarbon Material. *Jurnal Penelitian Pendidikan IPA, 11*(1), 45–51. https://doi.org/10.29303/jppipa.v11i1.9775

Farmer, S. C., & Schuman, M. K. (2016). A Simple Card Game to Teach Synthesis in Organic Chemistry Courses. *Journal of Chemical Education, 93*(4), 695–698. https://doi.org/10.1021/acs.jchemed.5b00646

Fasano, G., & Franceschini, A. (1987). A Multidimensional Version of the Kolmogorov–Smirnov Test. *Monthly Notices of the Royal Astronomical Society, 225*(1), 155–170. https://doi.org/10.1093/mnras/225.1.155

Gyang, N. O. (2025). Exploring the Level of Conceptual Understanding of Hydrocarbons Among Senior High Students. *School Science and Mathematics, 2025*(1), 1-10. https://doi.org/10.1111/ssm.18415

Habibzadeh, F. (2023). Data Distribution: Normal or Abnormal?. *Journal of Korean Medical Science, 39*(3), 1-20. https://doi.org/10.3346/jkms.2024.39.e35

Hake, R. R. (1998). Interactive-Engagement Versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

Hu, Y., Gallagher, T., Wouters, P., van der Schaaf, M., & Kester, L. (2022). Game-Based Learning Has Good Chemistry with Chemistry Education: A Three-Level Meta-Analysis. *Journal of Research in Science Teaching, 59*(9), 1499–1543. https://doi.org/10.1002/tea.21765

Karini, R. A., Fikroh, R. A., & Cahyani, V. P. (2022). Identification of Students' Misconceptions on Hydrocarbon Material Using a Four-Tier Multiple Choice Diagnostic Test. *Jurnal Pendidikan Kimia Indonesia, 6*(2), 79–87. https://doi.org/10.23887/jpki.v6i2.39022

Lestari, O., Priscylio, G., Copriady, J., & Holiwarni, B. (2020). The Use of Quartet Card Game on Hydrocarbon to Improve Learning Outcomes Ten-Grade Students. *Journal of Physics : Conference Series, 1567*(3), 1-20. https://doi.org/10.1088/1742-6596/1567/3/032096

Lisdiana, L., Windayani, N., & Helsy, I. (2025). Making UNO Smart Chemistry Card Game Media Based on the Nomenclature of Hydrocarbon Compounds. *Orbital : Jurnal Pendidikan Kimia, 9*(1), 43-55. https://doi.org/10.19109/ojpk.v9i1.26860

Lutfi, A., Aftinia, F., & Permani, B. E. (2023). Gamification: Game as a Medium for Learning Chemistry to Motivate and Increase Retention of Students' Learning Outcomes. *Journal of Technology and Science Education, 13*(1), 193–207. https://doi.org/10.3926/jotse.1842

Nora, N., & Lutfi, A. (2022). Development of Hy-Quiz Learning Media Based on Android to Improve Students' Learning Motivation in Nomenclature of Hydrocarbon Derivative Compounds Sub Material. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 10*(2), 206-216. https://doi.org/10.33394/j-ps.v10i2.4953

Nuriska, A., Kinanthi, R., & Azizah, U. (2025). Effectiveness of ADI-Based Student Worksheets on Students' Argumentation Skills in Chemical Equilibrium: A Pre-Experimental Study. *Journal of Environment and Sustainability Education, 3*(4), 635–643. https://doi.org/10.62672/joease.v3i4.177

Orvis, J., Sturges, D., Rhodes, S., White, K. J., Maurer, T. W., & Landge, S. M. (2016). A Mailman Analogy: Retaining Student Learning Gains in Alkane Nomenclature. *Journal of Chemical Education, 93*(5), 879–885. https://doi.org/10.1021/acs.jchemed.5b00551

Penberthy, J. K., Chhabra, D., Ducar, D. M., Avitabile, N., Lynch, M., Khanna, S., Xu, Y., Ait-Daoud, N., & Schorling, J. (2018). Impact of Coping and Communication Skills Program on Physician Burnout, Quality of Life, and Emotional Flooding. *Safety and Health at Work, 9*(4), 381–387. https://doi.org/10.1016/j.shaw.2018.02.005

Permata, N. N., & Lutfi, A. (2022). Development an Android-Based Game "Chemical Hydro Adventure" for Learning Hydrocarbon Material. *Jurnal Pendidikan Sains Universitas Muhammadiyah Semarang, 10*(2), 1–11. https://doi.org/10.26714/jps.10.2.2022.1-11

Purcell, C., Dibben, G., Hilton Boon, M., Matthews, L., Palmer, V. J., Thomson, M., Smillie, S., Simpson, S. A., & Taylor, R. S. (2023). Social Network Interventions to Support Cardiac Rehabilitation and Secondary Prevention in the Management of People with Heart Disease. *Cochrane Database of Systematic Reviews, 2023*(6), 1-20. https://doi.org/10.1002/14651858.CD013820.pub2

Rokhim, D. A., Rokayah, D. Y., Nabilah, S., & Alfarisi, F. S. (2021). The Effect of the "Hy-Bon Hydrocarbon" Edugame Media on Hydrocarbon Derivative Materials on the Learning Outcomes of Students in Class 12 MIPA 7 SMA Negeri 3 Sidoarjo. *Jurnal Pembelajaran Sains, 5*(2), 72–77. https://doi.org/10.17977/um033v5i2p72-77

Taheri, S. M., & Hesamian, G. (2012). A generalization of the Wilcoxon Signed-Rank Test and Its Applications. *Statistical Papers, 54*(2), 457–470. https://doi.org/10.1007/s00362-012-0443-4

Wood, J., & Donnelly-Hermosillo, D. F. (2019). Learning Chemistry Nomenclature: Comparing the Use of an Electronic Game Versus a Study Guide Approach. *Computers & Education, 141*(1), 1-20. https://doi.org/10.1016/j.compedu.2019.103615