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Integrating STEAM in Project-Based Learning to Foster Soft Skills in Higher Education

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ABSTRAK

Kemampuan soft skills *menjadi salah satu faktor esensial dalam mempersiapkan mahasiswa menghadapi tantangan dunia kerja yang semakin kompetitif. Namun, pembelajaran tradisional sering kali kurang memberikan perhatian pada pengembangan keterampilan non-teknis ini. Penelitian ini bertujuan untuk menganalisis pengaruh pembelajaran berbasis proyek yang terintegrasi STEAM (*Science, Technology, Engineering, Arts, and Mathematics*) terhadap peningkatan soft skills mahasiswa pada mata kuliah Kimia Organik, khususnya topik hidrokarbon. Penelitian ini menggunakan pendekatan kuantitatif dengan desain deskriptif-korelasional. Sampel penelitian dipilih secara purposive, melibatkan 33 mahasiswa yang mengambil mata kuliah Kimia Organik. Pengumpulan data memanfaatkan angket tertutup berbasis Google Form, sementara analisis data menggunakan regresi linear sederhana. Hasil penelitian menunjukkan bahwa metode pembelajaran berbasis proyek yang terintegrasi STEAM (PJBL-STEAM) memberikan pengaruh yang signifikan terhadap pengembangan* soft skills *mahasiswa, dengan nilai koefisien determinasi (R^2) sebesar 0,300, yang berarti metode ini menjelaskan 30% variasi dalam peningkatan* soft skills*. Sisanya dipengaruhi oleh faktor lain di luar penelitian. Penelitian ini menyimpulkan bahwa PJBL-STEAM tidak hanya efektif dalam meningkatkan kemampuan teknis mahasiswa tetapi juga berperan penting dalam mengembangkan keterampilan non-teknis yang relevan dengan tuntutan dunia profesional.*

ABSTRACT

Soft skills are essential factors in preparing students to face the increasingly competitive job market. However, traditional learning methods often pay less attention to the development of these non-technical skills. This study aims to analyze the impact of project-based learning integrated with STEAM (Science, Technology, Engineering, Arts, and Mathematics) on improving students' soft skills in the Organic Chemistry course, particularly in the topic of hydrocarbons. The research employs a quantitative approach with a descriptive-correlational design. The sample was selected purposively, involving 33 students who took the Organic Chemistry. Data were collected through a closed-ended questionnaire using Google Form, and the data analysis was conducted using simple linear regression. The results showed that the project-based learning method integrated with STEAM (PJBL-STEAM) had a significant impact on the development of students' soft skills, with a determination coefficient (R^2) value of 0.300. This indicates that the method explains 30% of the variation in soft skills improvement, while the remaining percentage is influenced by other factors beyond this study. In conclusion, this study highlights that PJBL-STEAM is not only effective in enhancing students' technical abilities but also plays a crucial role in developing the non-technical skills required in professional settings.

1. INTRODUCTION

School is a place to learn, work, and practice developing skills so that you are able to compete and enter the world of work (Fitriany, 2022; Ivonesti et al., 2020; Ivonesti1, 2018). Soft skills are knowledge or

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skills in non-academic or subjective fields that include character, understanding of values, art, drive (motivation), adaptation, communication, teamwork, problem solving, stress management, and leadership from within humans to actualize their abilities. (Singh Dubey & Tiwari, 2020). The research found that in the industrial era 4.0, soft skills affect a person's work readiness (Ayaturrahman & Rahayu, 2023; Tarigan & Fadillah, 2023; Widiyawati et al., 2024). The soft skills required include communication skills, teamwork skills, leadership skills, and problem-solving skills (Fauzan, 2020; Gunawan et al., 2019).

The importance of soft skills for the quality of human resources makes character education a must in learning. Therefore, in this study, the main focus is the development of students' soft skills as an effort to improve character in building quality human resources in accordance with the demands of the times. Based on the results of observations, organic chemistry courses still focus on improving students' academics and have not developed students' soft skills in class. The development of these soft skills is an indicator for students in carrying out their work. Success in work depends on 80% soft skills and the rest hard skills. (Giri & Nova, 2021; Setiawati & Mayasari, 2021). Other research also states that 85% of a person's success comes from soft skills and the rest from various things. (Novita et al., 2023). To shape educators or prospective teachers capable of understanding situations to achieve success, it is essential to provide learning experiences that develop soft skills. One of the efforts to enhance students' soft skills is through learning approaches that integrate multiple disciplines. This multidisciplinary learning approach is referred to as Science, Technology, Engineering, and Mathematics (STEM). In some contexts, the element of art is incorporated, transforming it into Science, Technology, Engineering, Arts, and Mathematics (STEAM). These integrated disciplines are interconnected, meaningful, and relevant, fostering students' interest and motivation to learn (Chung et al., 2022; Kurnia & Nasrudin, 2022; Yakman & Lee, 2012).

STEM learning supports the development of cognitive abilities, personal motivation, conceptual knowledge, social skills, problem-solving competencies, scientific discoveries, technological innovation, and mathematical calculations, aligning with the demands of 21st-century skills. The STEAM approach integrates science, technology, engineering, arts, and mathematics by focusing educational processes on problem-solving. STEM enables the integration of concepts and principles from these fields to develop products, processes, and systems that benefit human life, applying knowledge to real-world phenomena (Laseinde & Dada, 2024; Roehrig et al., 2021). Furthermore, STEM emphasizes the importance of developing problem-solving skills and fostering collaborative abilities, preparing students to compete globally and face future challenges (Ballatore & A. Tabacco, 2024; Mufakkirul et al., 2024; Olabiyi et al., 2021).

One commonly employed method in STEM education is the Project-Based Learning (PjBL) approach. PjBL is a learning model that emphasizes contextual learning through complex activities, guiding students to ask questions, design, solve problems, conduct investigations, make decisions, and work independently or in teams, The resulting projects often lead to tangible products (Ling et al., 2024; Loyens et al., 2023; Olabiyi et al., 2021; Omelianenko & Artyukhova, 2024). In PjBL, students engage in phases such as project assignment determination, project planning, scheduling agreements between lecturers and students, project monitoring, and assessment (Bergaoui & Ghannouchi, 2023; Delle-Vergini et al., 2024). This model focuses on problem-solving, integrating knowledge from various disciplines, thus offering a comprehensive learning experience. Although numerous studies have explored STEAM and PjBL individually, limited research integrates these approaches in organic chemistry learning to develop students' soft skills. The primary issue in this area is the lack of emphasis on soft skills development in organic chemistry education, particularly on hydrocarbon topics, which are essential for students' success in the professional world. The novelty of this research lies in integrating the STEAM approach into the PjBL model to enhance students' soft skills, a strategy rarely applied in organic chemistry courses. This study aims to develop a STEAM-PjBL-based learning model for hydrocarbon topics. The significance of this study lies in offering a new framework for organic chemistry education that adopts a holistic perspective, not only focusing on cognitive aspects but also integrating character and skill development, preparing students as future educators or professionals.

2. METHOD

This study employed a quantitative approach aiming to analyze the impact of integrating Project-Based Learning (PjBL) with STEAM (Science, Technology, Engineering, Arts, and Mathematics) on enhancing students' soft skills. The research population consisted of students from the Islamic University of North Sumatra (UISU) Medan enrolled in the Organic Chemistry course during the 2024 academic year. The sample was selected using purposive sampling based on specific criteria, namely students actively participating in the Organic Chemistry course during the designated period. A total of 33 students were included in the sample.

The research process began with the implementation of the STEAM-integrated PjBL method in the Organic Chemistry course, specifically on hydrocarbon topics. After completing the course, data were collected through a closed-ended questionnaire distributed to the sampled students. The questionnaire,

designed using Google Forms, contained statements addressing the research variables: STEAM-integrated PjBL as the independent variable and the enhancement of students' soft skills as the dependent variable. Each indicator of the dependent variable was represented by one or more statements in the questionnaire. Additionally, data collection was conducted through observation to monitor the application of the teaching method during the course sessions.

Before deployment, the questionnaire underwent validity and reliability testing to ensure the measurement instrument's accuracy and consistency. Validity testing involved measuring the correlation between each questionnaire item and the total score, while reliability testing employed Cronbach's Alpha coefficient. Data analysis was performed using SPSS software version 22. A simple linear regression analysis was used to examine the relationship between the independent and dependent variables. Hypothesis testing included a t-test to assess the significance of the relationship, an R-square test to measure the contribution of the independent variable to the dependent variable, and regression model interpretation to describe the relationship between the variables. This research was conducted at the Islamic University of North Sumatra (UISU) Medan, North Sumatra, in 2024. All research procedures adhered to ethical guidelines, including obtaining participants' consent and maintaining respondent confidentiality. With this structured methodology, the study aims to produce valid results regarding the influence of STEAM-integrated PjBL on improving students' soft skills in the Organic Chemistry course.

3. RESULT AND DISCUSSION

Result

After implementing the STEAM-Integrated PjBL learning process in the Organic Chemistry course, the author distributed a questionnaire to the sample group to measure the efficiency of the STEAM-Integrated PjBL approach in the course and assess students' soft skills levels. Once the data were collected, data processing was carried out. Since the variable measurement was conducted using a questionnaire, instrument testing was performed first, including validity and reliability tests (Ritonga et al., 2022; Tampubolon et al., 2023; Zuhri et al., 2024). The reliability test results are presented in Table 1.

Table 1. Table of Summary Validity Test of Instrument

Variable x	R_{count}	R_{Table}	Information	Variable y	R_{count}	R_{Table}	Information
1	0.656	0.361	VALID	1	0.542	0.361	VALID
2	0.563	0.361	VALID	2	0.577	0.361	VALID
3	0.593	0.361	VALID	3	0.537	0.361	VALID
4	0.545	0.361	VALID	4	0.688	0.361	VALID
5	0.569	0.361	VALID	5	0.551	0.361	VALID
6	0.640	0.361	VALID	6	0.536	0.361	VALID
7	0.671	0.361	VALID	7	0.599	0.361	VALID
8	0.547	0.361	VALID	8	0.512	0.361	VALID
9	0.574	0.361	VALID	9	0.583	0.361	VALID
10	0.577	0.361	VALID	10	0.580	0.361	VALID

A study is also considered reliable if the Cronbach's Alpha value is > 0.70 and if the Cronbach's Alpha value is < 0.70 then the study is considered less reliable. Based on the results of the reliability table test above, it is known that the Cronbach alpha value of variable x is 0.778 and the Cronbach alpha value of variable y is 0.740, both of which are greater than the Cronbach alpha value of 0.7. Thus, it can be concluded that the research instrument used to measure variables x and y is reliable. Chart of normality test showed in Figure 1.

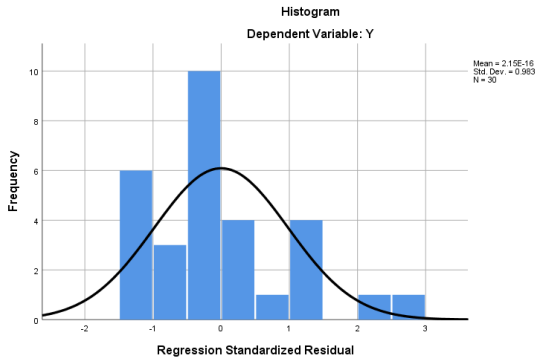

Figure 1. Chart of Normality Test

Based on the histogram graph above, a distribution pattern is seen that deviates to the right, which means the data is normally distributed. So the data processed for the Normality test can be used and is normally distributed. Based on the output results of the Scatterplot above, it can be seen that the points are spread out and do not form a wave pattern, widening then narrowing. So it can be concluded that the data in this study does not have a heteroscedasticity problem. Anova result showed in Table 2.

Table 2. ANOVA

Parameters			Sum of Squares	df	Mean Square	F	Sig.
X.Y	Between Groups	(Combined)	182.250	14	13.018	0.672	0.769
		Linearity	1.197	1	1.197	0.062	0.807
		Deviation from Linearity	181.053	13	13.927	0.719	0.722
	Within Groups		290.717	15	19.381		
	Total		**472.967**	**29**			

Based on the results of the linearity test, the linearity significance deviation value was obtained as 0.722 > 0.05 so it can be concluded that there is a linear relationship between the variables. Autocorrelation test and keofetion R square. Result = dU < d < 4-dU then 1.489 < 2.004 <2.511 so the conclusion is data does not contain autocorrelation. Multicollinearity test showed in Table 3. In the Table 3, the multicollinearity statistic value VIF is 1.00 < 10.00, so the research data passes the multicollinearity test. Homogeneity test showed in Table 4.

Table 3. Summary of Multicollinearity Test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.798	7.034		1.768	0.000		
	Variable	0.580	0.182	0.050	3.463	0.792	1.000	1.000

Table 4. Summary of Test of Homogeneity of Variances result

		Levene Statistic	df1	df2	Sig.
Dependent Variable	Based on Mean	1.160	6	19	0.368
	Based on Median	0.869	6	19	0.535
	Based on Median and with adjusted df	0.869	6	11.249	0.546
	Based on trimmed mean	1.107	6	19	0.395

The p-value (0.546) is also greater than 0.05, indicating that the variances between groups remain homogeneous even after adjusting the degrees of freedom. The p-value (0.395) is greater than 0.05, meaning the variances between groups are also considered homogeneous based on the trimmed mean. So concluded that Based on all both testing methods, the p-values are greater than 0.05. Therefore, the variances between groups can be considered homogeneous. This homogeneity of variances satisfies the assumption required for certain statistical analyses, such as ANOVA. Summary of t test showed in Table 5.

Table 5. Summary of t-Test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.798	7.804		1.768	0.088
	X	0.580	0.167	0.548	3.463	0.002

Table 5 shows that Coefficient (X): 0.580, indicates a positive relationship between STEAM-PjBL learning and students' soft skills. From SPSS found t_{value}**:** 3.463 then t_{table} (α = 0.05, df = n-2): 2.048 and p-value (Sig.): 0.002 so the Analysis Steps are 1) Compare t_{value} with t_{table} that t_{value} (3.463) > t_{table} (2.048) and since the t_{value} is greater than the t_{table}, H_0 is rejected. Compare p_{value} with the significance level, then p_{value} (0.002) < α (0.05) Since the p_{value} is smaller than 0.05, H_0 is rejected. Based on the analysis that the null hypothesis (H_0) from this research is rejected, and the alternative hypothesis (H_a) is accepted. That means that STEAM-PjBL learning has a significant positive effect on students' soft skills. So, the interpretation from data is B coefficient of 0.580 indicates that every one-unit increase in STEAM-PjBL learning improves students' soft skills by 0.580 units. The very small p_{value} (0.002) further strengthens the conclusion that this

relationship is statistically significant. Therefore, STEAM-PjBL learning can be considered an effective approach to enhancing students' soft skills. The coefficient of determination is used to state the magnitude of the contribution of variable X to variable Y. Autocorrelation test and R square coefficient explains that the R square value or coefficient of determination (KD) is obtained which shows how good the regression model is formed by the independent interaction variables and the dependent variable. The R square value obtained is 0.300 which can convert that the independent variable X (PJBL steaming learning) has a contribution of 30% influence on variable Y (student skills) and 70% is influenced by other factors outside the variable.

Discussion

The results of this study indicate that implementing Project-Based Learning (PjBL) integrated with STEAM has a positive effect on enhancing students' soft skills in Organic Chemistry learning, particularly on the topic of hydrocarbons. These findings align with the research objectives, which were to identify and analyze the effectiveness of STEAM-PjBL in developing students' soft skills. From a theoretical perspective, these findings support previous theories suggesting that project-based learning enhances students' critical thinking, communication, and collaboration skills (Chistyakov et al., 2023; Rahmadhani & Ardi, 2024; Zulyusri et al., 2023). This result is also supported by research which states that STEAM integration into PjBL offers a holistic approach that combines various disciplines in improving students' analytical skills and creativity (Ammar et al., 2024; Megawati, 2024). However, these findings also indicate that the contribution of STEAM-PjBL to soft skills is not entirely dominant, as only 30% of the variation in soft skills is explained by this variable. This contrasts with certain studies claiming that STEAM-based learning methods can explain a larger contribution to soft skills development (Singh et al., 2024; Zhang & Jia, 2024). Such discrepancies may arise from contextual factors, such as cultural background, curriculum design, or limitations in the implementation of the learning method.

These findings enrich theories on project-based learning and STEAM integration by adding empirical evidence from a local context, specifically students at Universitas Islam Sumatera Utara. Practically, these results are relevant to higher education, particularly in enhancing graduates' competitiveness through the mastery of soft skills. By implementing this method, students not only gain academic understanding but also develop interpersonal and intrapersonal skills essential for the workplace, such as teamwork, problem-solving, and adaptability. A deeper analysis suggests that external factors, such as learning motivation, teaching quality, and the learning environment, are likely to influence the outcomes (Ariyatun & Octavianelis, 2020; Pixyoriza et al., 2022; Purwaningsih et al., 2020). Additionally, limited time for implementing the STEAM-PjBL method and differences in students' initial abilities may affect its effectiveness. This highlights the need for a more comprehensive approach to exploring other variables that may contribute to soft skills development (Ammar et al., 2024; Megawati, 2024).

This study has several limitations that should be acknowledged. First, the sample size was relatively small (33 students), making the findings less generalizable to larger populations. Second, data collection relied solely on closed-ended questionnaires, which may limit a deeper understanding of students' experiences with STEAM-PjBL learning. Third, the study focused on a single course, Organic Chemistry, so the findings may not be directly applicable to other learning contexts. Future research is recommended to expand the sample size, incorporate additional data collection methods such as interviews or case studies, and apply this approach in various courses to test the consistency of the results. In conclusion, this study successfully demonstrates that the implementation of STEAM-PjBL positively impacts the development of students' soft skills, although its contribution remains limited. These findings have important implications for the development of innovative learning methods in higher education and open opportunities for further research to explore more comprehensive approaches and relevant variables. Thus, the integration of STEAM-PjBL can serve as an effective strategy to support 21st-century learning needs.

4. CONCLUSION

The results of the regression analysis indicate that PjBL-STEAM provides a significant and positive contribution to the development of students' soft skills. The implications of this study indicate that the application of the PjBL-STEAM method can be an effective alternative to develop students' soft skills, which are very important to prepare them to enter the workforce. These findings also contribute to the advancement of higher education curricula, especially in courses that require an interdisciplinary approach, such as Organic Chemistry. Integrating STEAM into learning not only improves students' technical abilities but also develops non-technical skills that are relevant to future professional demands. Overall, this study provides strong evidence of the effectiveness of Project-Based Learning integrated with STEAM in improving students' non-technical skills. It is hoped that these findings will serve as a reference for the development of more interactive and relevant learning methods that are in line with the needs of the education sector and the professional world.

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