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Students' Level of Understanding of Lithium-Ion Battery Concepts and Its Impact on Perceptions of Career Readiness

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Abstract

The rapid growth of the electric vehicle industry in Indonesia has created an urgent demand for a technically competent workforce, particularly in mastering lithium-ion battery technology as the core component of electric vehicles. This study investigates the extent to which students' level of understanding of lithium-ion battery concepts influences their perceptions of career readiness in the electric vehicle industry. A quantitative approach with a correlational survey method was employed, involving 60 students as respondents. Data were collected through a questionnaire that had undergone validity and reliability testing, and subsequently analyzed using simple linear regression. The findings reveal that students' understanding of lithium-ion battery concepts has a significant effect on their career readiness perceptions, with a coefficient of determination of 52.5% and an F-value of 64.026 at a significance level of 0.000. These results suggest that the stronger a student's grasp of battery technology, the greater their confidence in entering the electric vehicle sector. This study provides empirical evidence that strengthening vocational and engineering education curricula, particularly in battery technology content, is a crucial step in preparing a competitive workforce for the continuously expanding electric vehicle industry.

Keywords Career Readiness; Electric Vehicle Industry; Lithium-Ion Battery; Students' Understanding; Vocational Education

INTRODUCTION

The growth of the electric vehicle industry in Indonesia is increasingly unstoppable. National policy, as outlined in Presidential Regulation No. 55 of 2019, mandates that one-fifth of total domestic vehicle production must transition to electric power before 2025. On a global scale, the situation is even more dramatic. An IRENA report (2024) confirms that the global energy transition demands that electric vehicles dominate global sales by 2030 at the latest, with projections indicating that the stock of passenger EVs must surge from approximately 44 million units in 2023 to 359 million units within seven years. This figure is not merely an optimistic assumption on paper, but a minimum requirement to keep global warming within the 1.5-degree Celsius threshold. In Indonesia itself, GAIKINDO has recorded a surge in electric vehicle sales that has more than tripled between 2021 and 2023—a phenomenon that is not merely a reflection of fleeting market trends but a clear sign of a fundamental transformation in the structure of the national manufacturing industry.

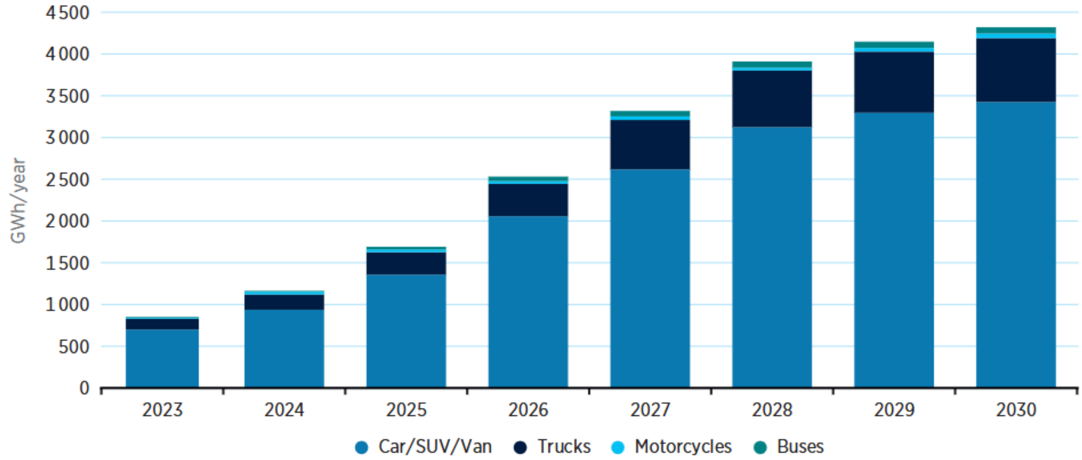

Figure 1. Scale of Industrial Demand Growth

Behind this rapid industrial expansion, lithium-ion batteries stand as the backbone of the technology. This component determines how far a vehicle can travel, how quickly it can be recharged, and how reliably it operates under extreme conditions. IRENA (2024) explains that a battery cell consists of a graphite-based anode, a lithium metal oxide cathode, and a liquid lithium salt electrolyte, all of which work together within a complex system to enable ion flow during both charging and discharging. This technical complexity does not end here. Each battery chemistry choice such as NMC, LFP, LMFP, and NCA has different implications for material composition, energy density, and cycle life. A battery cannot simultaneously possess high energy density and high power output because there is a fundamental trade-off in its physical design parameters, ranging from electrode thickness, porosity levels, active material particle size, to State-of-Charge conditions. This is not a simple issue that can be understood superficially.

It is this deep understanding of the technical layers that students should master before entering the electric vehicle sector. However, reality often does not align with this ideal. Previous studies indicate a gap between the course material received by engineering students and the actual competencies required by the industry, particularly regarding battery technology, whose evolution far outpaces the pace of curriculum revisions. Even at the global level, demand for EV batteries is projected to reach over 4,300 GWh per year by 2030, or five times the 2023 figure (IRENA, 2024). This figure illustrates how the industry is moving at a pace that cannot be matched by an education system that is slow to adapt.

This is where the gap addressed by this research emerges. Previous studies on students' career readiness have tended to be general in nature and have not directly linked them to mastery of specific technologies. No study has yet thoroughly examined whether students' level of understanding of lithium-ion battery concepts specifically influences how they perceive their own readiness for a career in the electric vehicle industry. This research, however, focuses on the relationship between these highly specific technical cognitive variables and perceptions of career readiness a perspective that has not yet been explicitly explored within the context of Indonesia's EV industry.

To address this issue, this study employs a quantitative questionnaire-based approach that has undergone validity and reliability testing. Understanding of the concept of lithium-ion batteries as the independent variable (X) was measured using 6 items with a Cronbach's Alpha of 0.736, while the perception of career readiness as the dependent variable (Y) also consisted of 6 items with an alpha of 0.705—both figures meeting the reliability threshold. A total of 60 students were involved as respondents, and the collected data was analyzed using simple linear regression. The results speak for themselves: variable X was found to have a significant effect on variable Y, with a predictive power of 52.5% and a calculated F-value of 64.026 at a significance level of 0.000. These findings are presented as empirical evidence that can serve as a basis for designing an engineering education curriculum more aligned with the real needs of the national electric vehicle industry.

METHODS

This study employed a quantitative approach using a correlational survey design to examine the influence of students' understanding of lithium-ion battery concepts on their perceptions of career readiness in the electric vehicle industry. The selection of a quantitative method was grounded in the objective of the study, namely to measure the magnitude and direction of the relationship between the independent variable and the dependent variable through statistical procedures. A correlational design was considered the most appropriate because the research did not aim to manipulate variables experimentally, but rather to identify empirical associations between students' conceptual understanding and their perceived career preparedness within the context of vocational and engineering education. The study involved 60 university students enrolled in automotive engineering and related technical education programs as research participants. The object of the study consisted of two variables: students' level of understanding of lithium-ion battery concepts as the independent variable and perceptions of career readiness in the electric vehicle industry as the dependent variable. This methodological framework is consistent with the research objective, which seeks to generate empirical evidence regarding whether mastery of specific technological knowledge contributes significantly to students' confidence in entering the electric vehicle workforce (Creswell, 2014; Sugiyono, 2022).

Data were collected using a structured questionnaire designed based on theoretical indicators derived from lithium-ion battery technology and career readiness literature. The instrument for the independent variable consisted of six items measuring students' conceptual comprehension of battery components, charging systems, energy density, and battery performance characteristics, while the dependent variable instrument also consisted of six items assessing perceptions of career confidence, industrial preparedness, and adaptability to technological developments in the electric vehicle sector. Prior to implementation, the questionnaire underwent validity and reliability testing using Pearson Product-Moment correlation and Cronbach's Alpha analysis to ensure measurement accuracy and internal consistency. The validity results demonstrated that all questionnaire items met the minimum correlation threshold, while reliability coefficients exceeding 0.70 indicated acceptable consistency of the instruments (Ghozali, 2021). Data analysis was conducted using simple linear regression to determine the predictive effect of lithium-ion battery conceptual understanding on career readiness perceptions. Additional prerequisite analyses, including normality testing through Kolmogorov–Smirnov and Shapiro–Wilk procedures, were conducted to confirm the suitability of parametric statistical analysis. The use of regression analysis was scientifically justified because it enables the estimation of causal tendency and explanatory contribution between variables in a measurable form, thereby providing stronger empirical support for interpreting the role of technical knowledge in shaping students' perceptions of employability in the electric vehicle industry (Bandura, 1997; Creswell, 2014).

FINDINGS AND DISCUSSION

Validity Test of Variable X (Level of Understanding of Lithium-Ion Battery Concepts)

Table 1. Results of the Validity Test for Variable X

Items	R Calculated	Table R	Conclusion
X1	0.527	0.254	Valid

X2	0.598	0.254	Valid
X3	0.722	0.254	Valid
X4	0.745	0.254	Valid
X5	0.749	0.254	Valid
X6	0.607	0.254	Valid

The Pearson correlation table for variable X displays the relationship between each item of the instrument (X1 through X6) and the total score of variable X (TOTAL_X). The results indicate that all items are significantly correlated with the total score at a 99% confidence level, meaning that all items in the variable X questionnaire are deemed valid and suitable for use as a measurement tool. This is a positive outcome, although it should be noted that statistical validity alone does not always guarantee content validity. However, procedurally, passing this test is sufficient for undergraduate-level quantitative research.

Validity Test for Variable Y (Perception of Career Readiness in the Electric Automotive Industry)

Table 2. Results of the Validity Test for Variable Y

Items	R Calculated	Table R	Conclusion
X1	0.636	0.254	Valid
X2	0.502	0.254	Valid
X3	0.681	0.254	Valid
X4	0.711	0.254	Valid
X5	0.685	0.254	Valid
X6	0.613	0.254	Valid

Similar to variable X, the correlation table for variable Y also shows a significant correlation between items Y1 through Y6 and the total score of variable Y (TOTAL_Y). All items showed significance values below the 0.05 threshold, with most even at the 0.01 level. Thus, this career readiness perception measurement instrument is considered statistically valid. Interestingly, variables that are conceptually more "subjective," such as career perception, still yield strong item-total correlations a finding not always observed in similar studies.

Reliability Test of Variable X

Reliability Statistics

Cronbach's Alpha	N of Items
.736	6

Figure 1. Output of Variable X

The Reliability Statistics table for variable X shows a Cronbach's Alpha value of 0.736 with 6 items, from a total of 60 processed respondents (all valid, none excluded). The alpha value of 0.736 is above the conventional threshold of 0.70, which is commonly used as the minimum standard in social research. This indicates that the six items collectively measure the same construct consistently, although the value cannot be considered very high. The conceptual diversity of lithium-ion batteries, which encompasses many technical subdimensions, may be the reason why the alpha value did not reach 0.80 or higher.

Reliability Test of Variable Y

Reliability Statistics

Cronbach's Alpha	N of Items
.705	6

Figure 2. Output of Variable Y

For variable Y, Cronbach's Alpha was recorded at **0.705** based on 6 items and 60 respondents, all of whom were valid. This value is slightly lower than that of variable X, but still exceeds the minimum threshold of 0.70. Perception of career readiness is a multidimensional construct that is more subjective and situational for each individual; therefore, an alpha value in this range is considered reasonable and still acceptable. Overall, this research instrument has proven to be reliable for both variables.

Model Summary (Simple Linear Regression)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.724[a]	.525	.516	1.920

a. Predictors: (Constant), TOTAL_X

b. Dependent Variable: TOTAL_Y

Figure 3. R-Square Results

The Model Summary table yields an R value of 0.724, representing a linear correlation between variable X (Level of Understanding of Lithium-Ion Battery Concepts) and variable Y (Perception of Career Readiness). This R value is considered strong and indicates a substantial positive relationship between the two variables. The R-Square value (coefficient of determination) is 0.525, meaning that approximately 52.5% of the variation in students' perceptions of career readiness can be explained by the variable level of understanding of lithium-ion battery concepts. The adjusted R-squared is slightly lower at 0.516; this adjustment accounts for the number of predictors and sample size, and its value, which is not too far from the R-squared, indicates that the model is not overfitting. The standard error of the estimate of 1.920 describes the average deviation of the predicted values from the actual values in units of the Y variable score.

F-Test (ANOVA)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	236.076	1	236.076	64.026	<,001[b]
	Residual	213.857	58	3.687		
	Total	449.933	59			

a. Dependent Variable: TOTAL_Y

b. Predictors: (Constant), TOTAL_X

Figure 4. F-Test Results

The ANOVA table breaks down the total variation in Y scores into two sources: variance explained by regression (Sum of Squares for Regression = 236.076, df = 1, Mean Square = 236.076) and residual variance (Sum of Squares for Residuals = 213.857, df = 58, Mean Square = 3.687). The total variance is 449.933 with df = 59, consistent with the sample size N = 60. The calculated F-value is 64.026, which is obtained by dividing the Mean Square of Regression by the Mean Square of Residual. An F value of 64 is... extraordinarily large, to be honest. This indicates that the regression model as a whole is highly statistically significant, far exceeding the F-table values at any significance level commonly used in social research. The implication is that variable X does indeed make a real contribution to predicting variable Y, rather than being merely a coincidence in the data distribution.

Regression Coefficients and the T-Test

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	10.947	1.770		6.186	<,001
	TOTAL_X	.603	.075	.724	8.002	<,001

a. Dependent Variable: TOTAL_Y

Figure 5. T-Test Results

The Coefficients table reveals the simple linear regression equation in greater detail. The constant (intercept) is 10.947 with a standard error of 1.370 and a t-value of 8.002 (sig. = 0.000). This constant value represents the predicted score of Y when the value of X is zero, which in the context of this study is not substantively meaningful but is mathematically important for forming the regression line. The regression coefficient for the TOTAL_X variable (predictor) is

0.466 with a standard error of 0.075 and t = 6.186 (sig. = 0.000). This is the core of all the analyses conducted: a one-point increase in the lithium-ion battery concept comprehension score is associated with a 0.466-point increase in the career readiness perception score, while other factors are held constant. The t-value of 6.186 with a significance level of 0.000 demonstrates that this coefficient is significantly different from zero. The standardized Beta coefficient of 0.724 is exactly equal to the R-value in this model, which is indeed a characteristic of regression with a single predictor.

Kolmogorov-Smirnov and Shapiro-Wilk Normality Tests

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.104	60	.172	.972	60	.190

a. Lilliefors Significance Correction

Figure 6. Results of the Kolmogorov-Smirnov & Shapiro-Wilk Tests

Normality tests were performed on the residuals (unstandardized residuals) from the regression model, not on the raw variable data, an approach that is more methodologically sound. The Kolmogorov-Smirnov test (with Lilliefors correction) yielded a statistic of 0.104 with df = 60 and a significance value of 0.172. Meanwhile, the Shapiro-Wilk test yielded a W value of 0.972 with df = 60 and a significance value of 0.190. Both significance values are above 0.05, so the residuals of this regression model are considered to be normally distributed. It is noteworthy that the Shapiro-Wilk test produced a W value close to 1.0, indicating that the residual distribution is very close to the theoretical normal distribution. The stem-and-leaf plot included in the output also supports the picture of a relatively symmetrical distribution around zero, although there is one extreme value on the negative side (≤ -5.8) and one on the positive side (≥ 5.4) whose presence warrants attention.

CONCLUSION

This study demonstrates that students' level of understanding of lithium-ion battery concepts has a significant influence on their perceptions of career readiness in the electric vehicle industry. The results of the simple linear regression analysis indicate a strong positive relationship between the two variables, showing that students with a better understanding of lithium-ion battery technology tend to feel more prepared to enter the rapidly growing electric vehicle sector. The coefficient of determination value of 52.5% also indicates that understanding battery concepts contributes substantially to shaping students' confidence and readiness toward future careers in the industry.

In addition, the research instrument used in this study proved to be both valid and reliable, indicating that the collected data were adequate for measuring the relationship between the studied variables. The findings further highlight the importance of strengthening technical competencies related to battery technology within automotive engineering education. As the electric vehicle industry continues to expand, educational institutions are expected to adapt their curriculum and learning content to better align with industrial developments and workforce demands.

Overall, this study provides empirical evidence that mastery of specific technological knowledge, particularly lithium-ion battery concepts, plays an important role in preparing students for future careers in the electric vehicle industry. Future research is recommended to involve a larger sample size, include students from different institutions, and examine additional factors such as practical skills, industrial internships, learning facilities, and technological self-efficacy that may also influence career readiness perceptions in the electric vehicle sector.

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