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The influence of communication and student engagement on higher order thinking skills in automotive vocational education

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ABSTRACT

Higher order thinking skills (HOTS) are essential in vocational and engineering education; however, empirical evidence explaining how communication and student engagement jointly shape the development of HOTS remains limited, particularly in automotive contexts. This study aims to examine the partial and simultaneous influence of communication and student engagement on students' HOTS, including problem-solving, critical thinking, and creativity. An ex post facto quantitative correlational design was employed, involving 208 undergraduate and diploma students from the Automotive Engineering Education and Vocational programs at Universitas Negeri Yogyakarta. Data were collected using validated questionnaires, and multiple linear regression analysis was conducted to determine both independent and combined effects of the predictor variables. The findings reveal that communication and student engagement each exert a positive and significant influence on HOTS, while their simultaneous contribution explains 71.9% of the variance in students' HOTS scores. These results indicate that students who actively communicate, participate, and engage cognitively, behaviorally, emotionally, and agentically demonstrate stronger analytical, reflective, and creative thinking abilities. The study confirms that communication and engagement are not merely supporting attributes, but key drivers of advanced cognitive development in automotive vocational education. Implications highlight the importance of designing interactive and collaborative learning environments that foster participation and meaningful academic involvement to prepare students for increasingly complex professional challenges.

INTRODUCTION

Higher-order Thinking Skills (HOTS) are increasingly important in contemporary educational and professional environments because they equip individuals with the ability to analyze, evaluate, make decisions, and generate new ideas beyond basic knowledge recall (Safitri et al., 2019; Tanujaya et al., 2017). These skills, which include creative thinking, problem-solving, and critical thinking, allow learners to navigate complex situations and develop innovative solutions to challenges (Abosalem, 2016). Rather than merely memorizing facts, learners with HOTS interpret and apply information in new contexts, thereby fostering deeper understanding. In an increasingly complex world, these skills are essential for adapting to technological, economic, and societal changes, particularly in relation to long-term productivity (Walters-Williams, 2022). For instance, businesses now prioritize employees who can think critically and independently, demonstrating the ability to innovate and make informed decisions in fast-changing environments.

Higher-order thinking skills have a pivotal role in academic achievement (Teemant, 2016), work readiness (Hasan & Pardjono, 2019), and career success (Rad & Forbes, 2017). In education,

HOTS enable individuals to move beyond rote memorization by encouraging them to analyze, evaluate, and apply knowledge in new contexts. This deeper engagement with learning material fosters better understanding, long-term retention, and improved academic performance. Students who develop these skills are better equipped to tackle complex problems, construct well-reasoned arguments, and synthesize information from multiple sources, which are essential for excelling in advanced academic tasks, such as research and critical writing. These abilities are also reflected in performance on standardized tests, projects, and assignments that require higher-order thinking.

In the professional sphere, HOTS are essential for navigating the demands of modern careers, particularly in industries that require creativity, problem-solving, and innovation (Brandt, 2023). Individuals with strong higher-order thinking skills can approach challenges with a critical and reflective mindset, generate novel solutions, and make informed decisions. These skills are increasingly sought after by employers, who value employees capable of independent thinking, adaptability, and leadership. For example, in fast-evolving fields like technology, business, and healthcare, the individual's capability to think critically and creatively is crucial for staying competitive and driving progress (Wu et al., 2018). In essence, HOTS provide a foundation for continuous learning, intellectual growth, and professional success (Yuniarti et al., 2024).

Communication is a critical factor influencing the development of individuals' HOTS (Afikah et al., 2022). It refers to an individual's ability to communicate information effectively and efficiently through spoken, written, and non-verbal means (Arumugam et al., 2021; Rahman et al., 2024; Tong et al., 2021). When learners participate in discussions, group activities, and problem-solving projects, they communicate with one another and are more likely to engage in reflective thinking, challenge their own ideas, and consider multiple perspectives. This collaborative learning environment fosters communication skills (Ghavifekr, 2020), which are vital for articulating complex thoughts, asking meaningful questions, and responding to others' arguments. According to Vygotsky's social constructivist theory, the learning process is inherently social, and cognitive development is strongly influenced by interactions with peers and teachers (Vygotsky, 1978). Communication helps students externalize their thinking, clarify misunderstandings, and build on others' ideas, further strengthening their cognitive abilities (Gillies, 2023).

Previous studies have shown that communication is a crucial factor influencing students' HOTS. Furthermore, previous research has shown that student engagement in active learning activities, such as classroom debates, peer discussions, and collaborative projects, enhances critical thinking skills and overall academic achievement (Bean & Melzer, 2021; Huda et al., 2023; Prince, 2004). These activities encourage students to move beyond passive learning, allowing them to question, evaluate evidence, and make connections between ideas, which are fundamental to HOTS (Singh & Marappan, 2020). Thus, promoting student engagement and open communication in the classroom not only supports a deeper understanding of content but also enhances the cognitive processes that underpin HOTS.

Numerous studies have investigated the relationship among communication, engagement, and higher-order thinking skills (Bean & Melzer, 2021; Huda et al., 2023; Rachmad et al., 2024). However, previous studies have typically examined communication and engagement as separate factors influencing cognitive outcomes. Very few have analyzed their combined effect on the development of HOTS within a vocational setting. The lack of empirical evidence addressing how these two social-cognitive variables jointly contribute to HOTS formation among vocational students represents a significant gap in the literature.

Moreover, most of these studies have focused on secondary education or disciplines in higher education other than automotive engineering. In automotive engineering education, learning activities typically combine theoretical and practical experiences, both of which are essential for developing the HOTS currently demanded in the field (Sonal et al., 2024). Theoretical activities might involve analyzing complex systems, studying vehicle dynamics, understanding thermodynamics, or applying mathematical models to real-world challenges (Mitchell et al., 2019). These tasks require individuals to engage in critical and creative thinking, data analysis, and problem-solving, pushing them to move beyond simple recall of facts to applying and synthesizing knowledge. This theoretical foundation is crucial for understanding the principles that underpin automotive engineering.

Practical activities, such as hands-on work in workshops, simulation exercises, and lab experiments, complement theoretical learning by allowing students to apply abstract concepts to tangible problems (Ariza, 2023; Mayombe, 2024). For instance, students might be tasked with diagnosing engine performance issues, designing and testing new automotive components, or using software tools to simulate vehicle behavior under different conditions. These practical tasks challenge students to think creatively, troubleshoot real-world problems, and draw informed conclusions based on experimental findings during the learning process. Engaging in such hands-on activities helps students bridge the gap between theory and practice, fostering deeper cognitive understanding and innovative problem-solving (Miterianifa et al., 2021).

By combining theory and practice, this integrated learning approach not only helps learners grasp complex concepts but also enhances their HOTS by encouraging them to analyze, evaluate, and create new solutions (Purnamawati & Saliruddin, 2017). This method of learning mirrors real-world engineering challenges, making students better equipped to handle complex problems in their future careers. Hence, this study aims to address this gap by examining the influence of automotive engineering students' communication and engagement on their higher-order thinking skills. First, it examines the individual effects of communication and engagement on students' higher-order thinking skills. Second, it examines the simultaneous effects of communication and engagement on automotive engineering students' HOTS.

RESEARCH METHOD

This ex post facto study employed a quantitative correlational design to examine the relationships between communication, student engagement, and higher-order thinking skills (Figure 1). A linear regression analysis was performed to identify and assess the influence of student communication and engagement on their HOTS. The analyses were performed using SPSS version 23 to determine the partial and simultaneous effects of both factors on automotive engineering students' higher-order thinking skills.

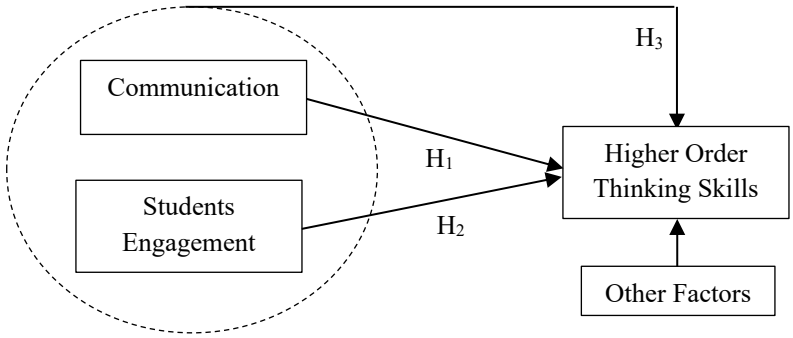

Figure 1. Research Framework

Data were collected using a questionnaire developed based on Hwang et al. (2018) to measure students' communication and higher-order thinking skills. Six items were used to measure students' communication (for example: "I am verbally and nonverbally supportive of other people"). The Cronbach's Alpha coefficient for the communication instrument was 0.90. The assessment of higher-order thinking included three subvariables: problem-solving (4 items, For example: "I am willing to face problems and make an effort to solve them"), critical thinking (4 items, for instance: "I consider several alternatives to a problem before I answer"), and creativity (3 items, for example: " I like to try something new"). The reliability coefficients for these three variables were 0.85, 0.84, and 0.80 (problem-solving, critical thinking, and creativity, respectively).

Meanwhile, the student engagement instrument was developed based on Reeve and Tseng (2011). It had a Cronbach's Alpha coefficient of 0.82, indicating adequate internal consistency. The assessment of student engagement consisted of four subvariables: behavioral (5 items, for example: "I pay attention in class"), agentic (3 items, for example: "During class, I express my preferences and opinions"), cognitive (4 items, for example: "When I study, I try to connect what I am learning

with my own experiences), and emotional (3 items, for example: "I Enjoy learning new things in class").

The population in this study consisted of students from the Engineering Faculty and the Vocational Faculty at Universitas Negeri Yogyakarta, with a research sample of 208 students from the undergraduate automotive engineering education program and the diploma program. The instruments were distributed to the students online using Google Forms through teaching groups and course instructors over a three-week period. The data were analyzed using multiple linear regression in SPSS to examine the influence of communication and student engagement on higher-order thinking skills.

RESULT AND DISCUSSION

Results

Instrument validity and reliability

The validity and reliability of the instruments were assessed using SPSS version 23. The results of the validity and reliability tests are presented in Table 1.

Table 1. Validity and Reliability of the Instrument

No.	Variable (N)	Validity	Reliability
1.	Communication	0.718** ~ 0.815**	0.868
2.	Students Engagement	0.592** ~ 0.824**	0.943
3.	Higher Order Thinking Skill	0.636** ~ 0.775**	0.913

Note. ** = Significant (p = 0.01)

Based on the outputs of the instrument's validity and reliability assessments, the instruments used to measure student's communication, engagement, and higher-order thinking skills demonstrated excellent values. The Cronbach's Alpha reliability coefficient for all three variables were above 0.800, showing a high level of consistency. Meanwhile, the item-total correlation coefficients varied from 0.592 to 0.824, revealing that each item in the instrument significantly contributed to the total variable score. These testing ouputs indicate that the instruments used have successfully measured the targeted constructs accurately and reliably.

The partial effect of communication and engagement on student's higher order thinking skills

Table 2. The Partial Effect of Communication and Engagement on Student's Higher Order Thinking Skills

No.	Variabel	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1.	(Constant)	0.822	0.170		4.841	0.000
2.	Communication	0.333	0.051	0.324	6.531	0.000
3.	Students Engagement	0.589	0.049	0.597	12.009	0.000

$Y = a + b_1.X_1 + b_2.X_2$

$Y = 0{,}822 + 0{,}333X_1 + 0{,}589X_2$

The result (Table 2) reveals a constant value of 0.888, meaning that if all independent variables are 0, the result would be 0.822. The regression coefficients indicate that communication and student engagement positively and significantly influence students' higher-order thinking skills. A 1% increase in student communication will lead to a 0.333 increase in their level of thinking skills. Additionally, a one-unit increase in student engagement is associated with an increase in higher-order thinking skills, holding the other variable constant.

Furthermore, according to Wiratna (2014), if the calculated t-value is greater than the t-table value or if the *p-value* is less than 0.05, it shows that the independent variable has a partial effect on the dependent variable. The results indicate that communication and student engagement each have a significant effect on students' higher-order thinking skills. Communication had a significance value

of p < .001 and a t-value of 6.531, while student engagement had a significance value of p < .001 and a t-value of 12.009. These results support H1 and H2, indicating that students' communication and engagement positively affect their higher-order thinking skills.

The Effect of Communication and Engagement on Student's Higher Order Thinking Skills

Table 3. The Effect Communication and Engagement on Student's Higher Order Thinking Skills

No.	Model	Sum of Squares	df	Mean Square	F	Sig.
1.	Regression	54.040	2	27.020	262.789	0.000[b]
2.	Residual	21.078	205	0.103		
	Total	75.118	207			

According to Ghozali (2006), if the significance value is lower than 0.05, it indicates that the independent variable has a simultaneous effect on the dependent variable. The result of the study (Table 3) reveals the effect of both students' communication and engagement on their higher order thinking skills. The p-value was < .001, indicating a significant simultaneous effect of the two variables on students' HOTS. The results indicate that communication and student engagement simultaneously influence students' higher-order thinking skills. These results support H3.

Multiple Coefficient of Determination

Table 4 shows that the variables of communication and student engagement altogether influence the variable of higher-order thinking skills among students by 71.9%. Subsequently, the remaining 28.1% is affected by variables outside of this regression equation or those that were not analyzed.

Table 4. Results of Determination Coefficient

No.	Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.	Communication and Students Engagement	0.848	0.719	0.717	0.321

The results of the regression testing show a very strong positive relationship between the learners' communication and engagement with their higher-order thinking skills (R= 0.848). This positive relationship indicates that higher levels of communication and student engagement are associated with higher levels of HOTS. Additionally, the R^2 value of 0.719 indicates that 71.9% of the variance in higher-order thinking skills can be explained by communication and student engagement, meaning these factors have a positive and significant effect to the development of an individual's level of thinking skills. The adjusted R^2 value was 0.717, indicating that the model explained 71.7% of the variance in HOTS after adjustment for the number of predictors.

Furthermore, the standard error of the Estimate value is 0.321, indicating a relatively low level of error in predicting higher-order thinking skills. Overall, these results affirm that improvements in students' communication and student engagement can significantly enhance their critical, analytical, and creative thinking proficiencies.

Discussion

Communication skills are essential for enhancing student achievement (Laelah & Aeni, 2022). Good communication skills enable students to articulate their ideas clearly, listen attentively to others, ask questions to understand others' perspectives, and reflect on group activities and interactions while encouraging other group members to do the same (Maksum & Purwanto, 2019). The results indicate that communication significantly influences automotive engineering students' HOTS. This finding highlights the distinctive role of communication as a key determinant of students' HOTS, particularly in automotive vocational education. In the context of technological transformation and Industry 4.0, communication competence is no longer limited to verbal interaction but extends to collaborative problem-solving, digital communication, and interdisciplinary teamwork (Yuniarti et al., 2024). Communication reflects an individual's capacity

to convey ideas through language and words, which can be applied in both written and spoken formats. This includes skills such as articulating, explaining, describing, clarifying, listening, questioning, and sharing. This ability is a key determinant in understanding learning which subsequently fosters student's reflective learning and cognitive processes to acquire innovation in vocational contexts (Afikah et al., 2022; Gillies, 2023). Moreover, communication significantly impacts students' achievements in educational settings, aligning with the habits and lifestyles of millennials, which reflect communication technology when used wisely by students (Khoiri et al., 2021). Thus, these aspects contribute significantly to the development of university students' higher-order thinking skills through communication and engagement in learning and social projects.

Communication is important to foster individual's HOTS; however, student engagement is also necessary to achieve higher-order thinking in academic settings. This engagement can be observed through learners' participation in both structured and unstructured academic activities. Participation refers to the behaviors, emotions, and cognitive processes exhibited in the college environment and within the classroom. Student engagement encompasses three dimensions: emotional, cognitive, and behavioral engagement (Skinner, 2016; Teng & Wang, 2021). Bond et al. (2020) characterize student engagement in terms of the time, commitment, and involvement that students invest in the learning process over time, which is influenced by cognitive, behavioral, and emotional factors.

The results indicate that student engagement significantly influences students' higher-order thinking skills. Student involvement in classroom activities, including behaviors such as listening attentively, paying attention, and working diligently, contributes to students' ability to understand and process information more critically. Agentic engagement, which includes the habit of asking questions and expressing opinions, also enhances students' abilities to think creatively and critically. Additionally, cognitive engagement, manifested through students' efforts to connect learning materials with prior knowledge or experiences and to integrate various ideas, shows that they are increasingly trained to develop deep and analytical understanding. Finally, emotional engagement, characterized by curiosity and interest in learning new things, provides intrinsic motivation that encourages students to explore information further, which is crucial for enhancing higher-order thinking skills.

Overall, these four dimensions of student engagement contribute significantly to the development of higher-order thinking skills. Students who demonstrate greater engagement tend to dedicate their time and effort to the learning process (Yang et al., 2018). Research indicates that when students show strong engagement in the learning process, they exhibit full attention, actively participate in class discussions, and demonstrate interest and motivation during their studies (Reyes et al., 2012). Engagement is assessed based on the level of participation in classroom teaching activities, involvement in empowerment programs, seeking guidance from educators, and collaborating with peers (Rogmans & Abaza, 2019). High levels of student engagement in classroom activities can lead students to continuously invest time and energy in understanding the material, even when the learning process presents various obstacles and challenges.

The influence of communication and student engagement enables students to be involved in higher-order thinking, leading the student to actively learn independently in line with the demands and complexities of the current era. Students with strong higher-order thinking skills are considered to achieve greater success than those with only lower-order thinking abilities (Purnama & Nurdianingsih, 2019). Higher-order thinking skills should be a primary goal and emphasis in educational institutions (Abosalem, 2016) and serve as an important factor in enhancing student learning outcomes (Thompson, 2008). Educators generally agree that developing students' higher-order thinking skills is crucial for fostering and improving their ability to generate ideas.

Overall, this study extends the current theories related to factors influencing students' higher order thinking skills by providing empirical evidence from the automotive vocational education domain, reinforcing that communication and engagement are not merely supportive factors but core enablers of higher-order thinking skills. The results advocate for a practical implementation of vocational teaching strategies toward more collaborative, reflective, and student-centered models that align with 21st-century industrial competencies. However, this study has limitations because all participants were automotive engineering students from undergraduate education and diploma

programs. Students from other programs or departments may exhibit different patterns of results. Furthermore, other variables not examined in this study may influence students' higher-order thinking skills.

CONCLUSION

Based on the findings, communication and student engagement have a significant impact on automotive engineering students' HOTS. Effective communication enables students to articulate their ideas clearly, collaborate productively, and develop a better understanding of concepts and information. Meanwhile, students' active participation in academic and non-academic activities, including behavioral, emotional, and cognitive engagement, enhances their motivation and commitment to the learning process. Together, communication and engagement facilitate the development of higher-order thinking skills that are important for academic success and adaptation to contemporary demands. Hence, lecturers in automotive engineering should prioritize learning strategies that foster communication and enhance student engagement. By creating interactive and collaborative learning environments, educators can encourage students to think systematically and creatively and develop essential skills for academic success and lifelong learning. Action research or experimental research is recommended to examine the implementation of these findings in classroom activities. Additionally, HOTS should remain a primary focus of the educational process to improve students' academic achievement and depth of understanding.

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