

Content Analysis of The Quality of Engineering Education (QEE) in The Indonesian Junior High School Science Curriculum

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ABSTRACT

In Indonesia, the engineering component in STEM education is critical yet remains poorly understood. This study aims to assess the representation of engineering education using the Quality of Engineering Education (QEE) framework within the Science Curriculum Phase D. The method employed is content analysis using a descriptive quantitative and qualitative approach within the QEE framework developed by Moore (2014). The study reveals that 10 out of 12 QEE elements are identifiable within the curriculum, with the Engineering Tools (Etool) element being the most dominant. However, two elements remain absent: the Process of Design (POD) and Concepts of Engineering and Engineers (CEE). These findings indicate that the quality of Engineering Education at Phase D in Indonesia remains limited. The results suggest that the Indonesian Science Curriculum for Junior High Schools still needs further development so that STEM components are explicitly represented and can serve as a firm reference for teachers to begin implementing STEM-based learning.



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A. INTRODUCTION

STEM education has become a global focus in preparing the 21st-century generation. Many countries view this approach as key to fostering critical thinking, communication, collaboration, and creativity (4C) skills. Teachers perceive STEM as an integrative approach that promotes the development of 21st-century competencies (Dare et al., 2021). This model is supported by integrating science, technology, engineering, and mathematics, which fosters students' creativity, curiosity, and productivity (Kavak, 2023). Such integration efforts have been carried out internationally to prepare citizens capable of solving complex problems and making knowledge-based decisions (Ekiz-Kiran & Aydin-Gunbatar, 2021).

Specifically, the engineering component in education has been shown to contribute to enhancing creativity (Preca et al., 2023), problem-solving skills (Oh, 2025), argumentation skills (Armelia et al., 2025), and communication skills (Wu et al., 2023). Studies have demonstrated that integrating engineering into science and mathematics instruction can connect learning to real-world contexts and strengthen students'

conceptual understanding (Aydin-Gunbatar et al., 2018; Mathis et al., 2018). Moreover, cross-disciplinary approaches in engineering education have increased students' originality of ideas, particularly in written forms (Deo et al., 2020).

In line with this, many countries have explicitly implemented engineering education within their curricula. Nations such as Australia, the United Kingdom, Estonia, Hong Kong, South Africa, Turkey, and the United States have integrated engineering into their national curricula (Ekiz-Kiran & Aydin-Gunbatar, 2021). The Next Generation Science Standards (NGSS) in the United States position engineering equally with science and technology within the curriculum structure. Meanwhile, China continues to advance engineering education by referring to practices from Singapore (Ma et al., 2020).

In Indonesia, the *Kurikulum Merdeka*, gradually implemented since 2022, adopts a learning outcome-based approach structured around two key elements: the Science Understanding Element and the Science Process Skills Element. The curriculum also incorporates the *Profil Pelajar Pancasila* (Character of Pancasila Students), which defines six core student competencies, namely: faithful and noble in character, globally diverse, cooperative, independent, critical thinkers, and creative (Kemdikbud, 2020). Preliminary studies suggest that engineering elements are already observable within the curriculum, though not explicitly stated (Anisa Sari et al., 2022). These findings underscore the need for a systematic content analysis to determine the actual degree of engineering integration across these foundational documents.

Despite the growing global emphasis on engineering education, no study has systematically examined the extent to which engineering elements are embedded in Indonesia's curriculum using a standardized analytical framework. This study therefore aims to measure the degree of engineering integration within the Junior High School Science Learning Outcomes and the Character of Pancasila Students documents, using the Quality of Engineering Education (QEE) framework developed by Moore et al. (2014). This study aims to: (1) describe the distribution of engineering elements within the science understanding component; (2) describe the distribution of engineering elements within the process skills component; (3) describe the distribution of engineering elements within the Character of Pancasila Students component.

B. METHODS

This study employs a content analysis method with a mixed quantitative and qualitative approach. This approach was chosen because the study focused on systematically coding curriculum document content into the indicators of the QEE Framework (Moore et al., 2014). The quantitative dimension produces frequency data on the occurrence of each indicator, while the qualitative dimension provides contextual interpretation of the coded statements within the documents.

The analytical framework used was a coding rubric based on 12 indicators of K-12 Engineering Education quality within the QEE Framework, namely: Processes of Design (POD) with three sub-indicators (Problem and Background (POD-PB), Plan and Implement (POD-PI), Test and Evaluate (POD-TE)); Apply Science, Engineering, and Mathematics (SEM); Engineering Thinking (EThink); Conceptions of Engineers and Engineering (CEE); Engineering Tools (ETool); Issues, Solutions, and Impacts (ISI); Ethics; Teamwork (Team); and Communication Related to Engineering (Comm-Engr). The data collection instrument used was a five-point Degree of Agreement scale questionnaire (strongly agree to strongly disagree).

The study was conducted in May-July 2025 through face-to-face meetings, involving 10 reviewers consisting of three lecturers and seven students from the Physics Education

Study Program, Faculty of Teacher Training and Education, Mulawarman University. The objects of analysis were the Learning Outcomes (LOs) Document for Science Subject Phase D for the Junior High School/Islamic Junior High School/Package B Program Level Year 2022 and the Dimensions, Elements, and Sub-elements Document of the Character of Pancasila Students in the *Kurikulum Merdeka*, both obtained from the official website of the Agency for Education Standards, Curriculum, and Assessment (Kemdikbudristek, 2022). The review was focused on the details of the Science Understanding Element and Process Skills Element in the Learning Outcomes document, as well as the Elements and Sub-elements in each Dimension of the Pancasila Student Character document. The overall research procedure is shown in Figure 1.

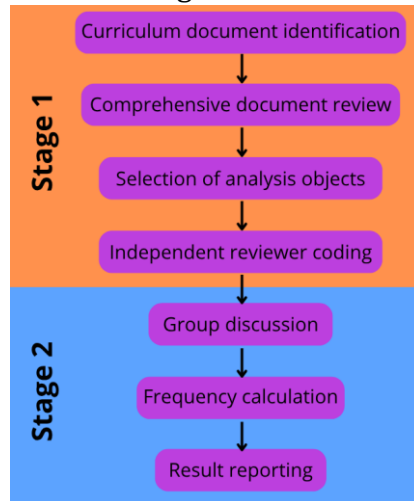


Figure 1. Research flow

The coding process was carried out in two stages. Each reviewer first independently analyzed the alignment of each LO’s content with the QEE indicators using the QEE framework as a guide. The individual analysis results were then collectively discussed with the Degree of Agreement questionnaire, see Table 1. It serving as a discussion framework to direct the deliberation and reach a coding consensus.

Table 1. Example of Degree of Agreement questionnaire

Element	LO	Analysis of Engineering	Degree of Agreement					Comments
			Strongly Agree	Agree	Neutral	Dissagree	Strongly Dissagree	
Science Understanding	able to classify living things and objects based on observed characteristics, identify the properties and characteristics of substances, differentiate between physical and chemical changes, and separate simple mixtures	No matching elements found						
	describe atoms and compounds as the smallest units of matter, and cells as the smallest units of living organisms; identify the organization of life systems and	Apply science, engineering, mathematics knowledge (SEM)						

	conduct analyses to find the relationship between organ systems and their functions, as well as disorders or abnormalities that arise in specific organ systems (digestive system, circulatory system, respiratory system, and reproductive system).							
...						

The quantitative analysis was conducted by calculating the frequency of occurrence of each QEE indicator in the documents using Equation (1), where n_i is the frequency of the i -th QEE element and N is the total occurrence of all QEE elements. The resulting values were then presented in diagrams to allow for comparative visualization across indicators.

$$QEE_i(\%) = \frac{n_i}{N} \times 100\% \quad (1)$$

C. RESULT AND DISCUSSION

1. Result

The LO Document for Science at the junior high school level (Phase D) shows that out of the 12 elements in the Quality of Engineering Education (QEE) framework, 10 elements were identified in the document based on the occurrence of relevant keywords. A total of 24 sentences in the LO document were found to contain keywords that serve as indicators of the presence of QEE elements.

Figure 3 shows the distribution of QEE elements in the curriculum. The results show that the keywords found are concentrated in the Science Understanding element (46%), while the Process Skills (25%) and Character of Pancasila Students (29%) elements have a smaller proportion. The dominance of QEE elements in the Science Understanding element shows that the curriculum is designed to emphasize mastery of concepts as its main focus.

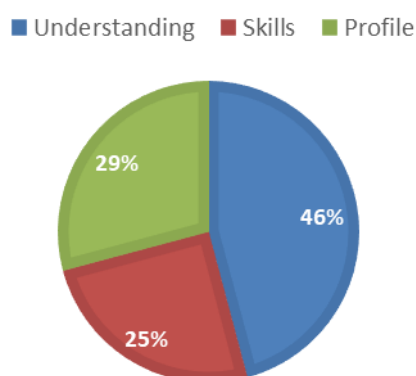


Figure 3. Distribution of Engineering Elements in the Science Curriculum

In general, there are 10 QEE elements in the science curriculum (Phase D). The most frequently appearing QEE elements are the ETool element at 21% and the EThink element at 17%, as shown in Figure 4. Meanwhile, the POD and CEE elements were not found. This pattern indicates that the QEE elements are still incomplete, suggesting that

the curriculum leans toward technical and cognitive aspects rather than the design process and the role of engineering.

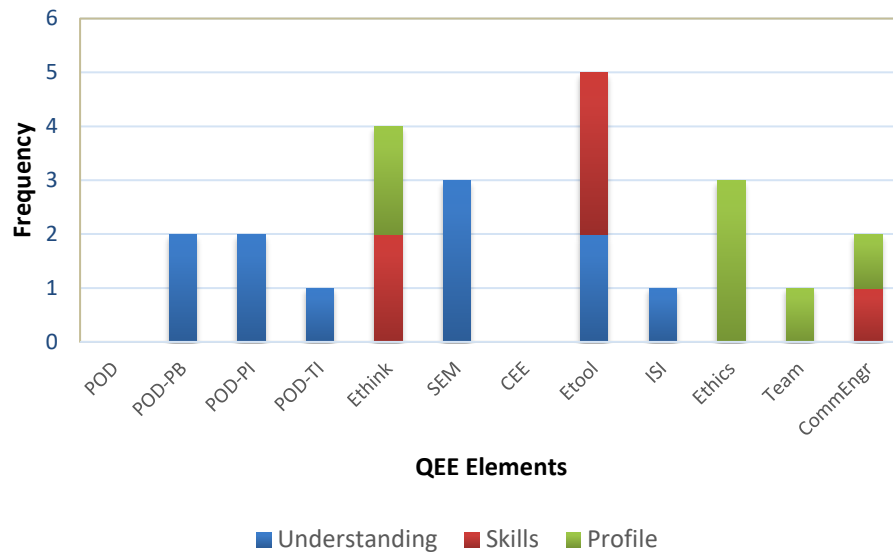


Figure 4. Distribution of Engineering Indicators in the Science Curriculum

Distribution of Engineering Elements in the Science Curriculum

In the Science Understanding component, the dominant QEE element is SEM (28%), followed by ETool (18%) and the POD component. However, the problem described in the POD component are not consistent, so POD is not considered to exist, as shown in Figure 6. The absence of POD indicates that the curriculum prioritizes scientific understanding rather than comprehensive technical practice.

Legend: ■ POD-PB ■ POD-PI ■ POD-TI ■ SEM ■ Etool ■ ISI

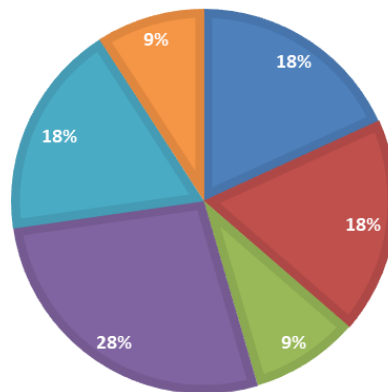


Figure 5. Distribution of Engineering Indicators in Understanding Science

Distribution of Engineering Elements in the Process Skills

The Process Skills component does not appear to contain many QEE elements. The most frequently found element is Etool (50%), while the least frequently found element is CommEngr (17%). Figure 6 illustrates the QEE element content in the Process Skills component. This component has the lowest QEE element content compared to other components.

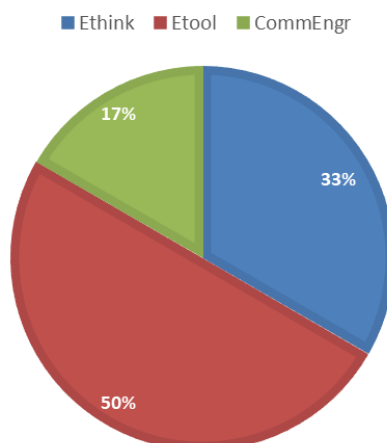


Figure 6. Distribution of Engineering Indicators in Process Skills

Distribution of Engineering Elements in the Character of Pancasila Students

In the Character of Pancasila Student component, the most dominant QEE element is Ethics (43%), while the least found element is Team (14%), as shown in Figure 7. This means that the Pancasila Student Profile component shows more ethics reflected by engineers than how engineers work together and communicate in presenting data. On the other hand, the presence of these four elements already shows good integration in guiding students to have the characteristics of an engineer.

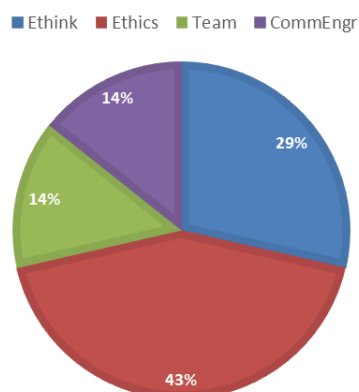


Figure 7. Distribution of Engineering Indicators in the Pancasila Student Profile

2. Discussion

The results of the curriculum content analysis show that the Phase D Science LOs Document contains almost all of the elements of QEE Moore et al., (2014). Of the 12 QEE elements, 10 were successfully identified. The presence of these elements indicates that the curriculum guides students to not only master science concepts, but also solve real-world problems. This orientation is consistent with the direction of the Indonesia curriculum, which is designed to improve the quality of education and facilitate the development of 21st-century students (Masjudin, 2024; Syahrir et al., 2024).

Etool, as shown in Figure 4, was found to be the most dominant element in the Science Phase D curriculum. The identified Etool element results from keyword analysis, indicating various tools in the learning process to ensure students understand how to use them (Ekiz-Kiran & Aydin-Gunbatar, 2021; Moore et al., 2014). This finding

is supported by previous studies that utilized learning tools to develop knowledge within the context of the *Kurikulum Merdeka* era (Ngongo et al., 2025). Similarly, Rahmaniar et al., (2023) found that Indonesian teachers have demonstrated good competence in developing STEM learning tools. Muchson et al., (2024) further explained that science learning tools have long been a popular research trend in Indonesia.

However, the absence of the POD and CEE elements, according to Figure 4, reduces the earlier optimism regarding the integration of engineering within the curriculum. POD is an indicator considered central to engineering education (Ekiz-Kiran & Aydin-Gunbatar, 2021). This process involves preparing, planning, and evaluating solutions at each stage, including redesigning and improving existing designs. POD is divided into three sub-indicators representing the main phases of design, namely POD-PB, POD-PI, and POD-TE (Moore et al., 2014). The analysis results show that POD-PB, POD-PI, and POD-TE were identified, but these elements appeared separately and not within a single coherent problem. The National STEM Learning Guide also states that engineering problems are always fully explained at the beginning (Bunyamin et al., 2025).

Therefore, POD is considered absent in the Phase D Science curriculum. This finding differs from the results of Ekiz-Kiran & Aydin-Gunbatar (2021), where POD-TE was generally unindicated in Turkish, leading to the absence of POD. The lack of a complete POD suggests that the engineering process is not yet understood as an iterative cycle but merely as an experimental activity. This may limit students' ability to recognize the relationship between design, testing, and solution improvement. This issue of limited problem-solving ability is supported by Santriyani (2024), who analyzed the results of students' Minimum Competency Assessment. This can also be interpreted as evidence that engineering integration in the Indonesian curriculum is still in its developmental phase. This is supported by the increasing trend of publications on related topics each year (Jin et al., 2024).

On the other hand, the CEE element, an indicator focusing on students' conceptual understanding of the engineering profession and engineering disciplines (Ekiz-Kiran & Aydin-Gunbatar, 2021; Moore et al., 2014), was also not identified in the curriculum. The absence of CEE has the potential to slow efforts to foster engineering career literacy at the junior high school level. According to Moore et al. (2014), early exposure to engineering professions is important for middle school students to strengthen the future STEM workforce. Ekiz-Kiran & Aydin-Gunbatar (2021) argued that CEE is not suitable for lower-grade students, such as kindergarten through grade two. Meanwhile, other studies on the impact of STEM-based learning have positively affected junior high school students' career choices (Amalia et al., 2024; Ozkan & Topsakal, 2023).

Both elements are equally important in shaping students' understanding of engineering. Without both, the understanding that develops tends to be incomplete or fragmented (Moore et al., 2014). The consequences can vary, one example is students who are skilled at designing and creating products but do not realize that these products are fundamentally intended to solve specific problems (Lee et al., 2018). This may also be related to students' levels of critical thinking skills (Nantara, 2021; Rosmalinda et al., 2021). Furthermore, there is also the possibility that students possess high engineering competencies but lack the interest to pursue a career as an engineer (Moore et al., 2015; Yuwono et al., 2025).

Overall, the identification of 10 out of 12 QEE elements in the Phase D Science Curriculum indicates the government's efforts to integrate engineering-oriented

competencies into science learning. This indicates that the curriculum no longer positions science as a standalone conceptual domain, but is beginning to focus on the use of science to produce solutions, which is in line with Moore's idea of the global need to introduce an engineering approach to STEM education. Indonesia government also published STEM education guidance as complementarity document to the curriculum (Bunyamin et al., 2025). However, the absence of the POD and CEE elements creates a significant gap. POD is at the core of the iterative engineering process (design-test-improve), while CEE provides an understanding of the engineering profession and context (Moore et al., 2014). The absence of these two elements implies that the curriculum does not yet fully facilitate learning experiences that enable students to act as problem solvers in real contexts. Thus, the integration of engineering in the Indonesia curriculum is still in the exploratory stage. These findings open up opportunities for curriculum policy refinement so that engineering competencies are not only present in terminology but also realized through systematic and holistic learning activities.

D. CONCLUSION AND SUGGESTIONS

Research on the analysis of QEE elements in Phase D Science LOs Documents has been conducted with the aim of identifying the extent to which engineering elements are integrated into the Indonesia curriculum. The Phase D Science Curriculum in Indonesia demonstrates progress in integrating elements of the QEE framework, with 10 out of 12 elements successfully identified. The dominance of the Etool element reflects a curriculum orientation that focuses primarily on the use of tools and scientific experiments. At the same time, a complete engineering process has not yet been clearly represented. The absence of the POD and CEE elements indicates that aspects of engineering thinking and professional engineering literacy have not yet been incorporated into the junior high school science curriculum.

This condition suggests that the integration of engineering within the Indonesia curriculum still requires further development to foster 21st-century skills effectively. Future curriculum developers and policymakers are recommended to explicitly incorporate the POD and CEE elements into Phase D Science LOs. Additionally, further research is needed to examine how these missing elements can be systematically embedded within the existing Indonesia curriculum without disrupting its core competency structure. Subsequent studies are also recommended to conduct systematic assessments using formal analytical frameworks to evaluate the integration of other STEM elements beyond engineering, as well as to extend such analyses to other educational levels beyond junior high school, in order to obtain a more comprehensive picture of STEM integration across the Indonesian national curriculum.

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