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# ENHANCING MATHEMATICAL COMPETENCIES IN TVET: LESSONS FROM ENGINEERING STAFF IN MALAYSIAN MANUFACTURING SECTORS

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**ABSTRACT**
Technical and Vocational Education and Training (TVET) programmes are crucial in providing the skilled workforce required by various industrial sectors in Malaysia. Mathematical knowledge and skills are essential foundations in TVET programmes as they equip students with the numerical skills, measurement, problem-solving abilities, and logical reasoning needed in various skill areas. However, studies show that TVET students face weaknesses in mathematics, such as poor understanding of basic concepts, weak calculation and problem-solving skills, and difficulties in applying mathematical concepts to new situations related to their skill areas. To overcome these weaknesses, new approaches in mathematics teaching and learning are needed, including emphasis on mathematical applications in skill areas, more effective pedagogy, and adequate training for instructors. Due to the complexity of problems that engineering staff need to solve, they require training in real-life problem-solving scenarios. MBOT accreditation guidelines emphasise the critical importance of developing mathematical competencies in producing versatile graduates who can apply mathematical knowledge to address real-world challenges in their respective disciplines. Therefore, a phenomenological approach was used in this study to identify mathematical competencies (MC) among engineering staff serving in manufacturing workplaces. Data were collected through intensive interviews, and phenomenological reduction techniques were used for data analysis. The findings show that mathematical competencies frequently used by engineering staff include Manage to Gather Data Problem Handling, Tools management, and Self-mathematical Decision. This study can provide input to instructors on developing mathematical competencies relevant to real-life problem-solving in TVET academic activities and programmes at their respective institutions.

**Keywords:** Mathematical competencies, TVET, Workplace, student TVET, Phenomenological
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## INTRODUCTION

Technical and Vocational Education and Training (TVET) plays a critical role in human capital development and developing a skilled workforce in Malaysia (Ministry of Education Malaysia,2023) (Economic Planning Unit, 2022). TVET offers training programmes that provide practical skills and technical knowledge required by various industrial sectors such as engineering, manufacturing, hospitality, and tourism (Skills Development Department,2022). This helps meet the demand for skilled labour and enhances the employability of students with skills required by employers (Tarzimah & Thamby Subahan, 2010).

TVET also contributes to economic and industrial development in Malaysia by producing a skilled workforce that supports economic growth and industrial development ) (Economic Planning Unit, 2022). This helps maintain Malaysia's competitiveness in an increasingly competitive global environment. Some TVET programmes also expose students to entrepreneurial and innovation skills, encouraging creative thinking and fostering an entrepreneurial spirit (Ministry of Education Malaysia,2023)(Skills Development Department,2022).TVET provides an alternative pathway to higher education and enables students to upgrade their skills and knowledge employers (Tarzimah & Thamby Subahan, 2010)(Juandi, 2021). This can increase social mobility and open up wider educational opportunities. Therefore, TVET plays an important role in developing a skilled workforce, supporting economic development, encouraging entrepreneurship, and increasing educational opportunities in Malaysia.

One of the weaknesses often faced by vocational and technical education and training (TVET) students is poor performance in Mathematics subjects. This has been identified in several studies and reports. According to a study by Natakoji & Wilson (2018), TVET students in Malaysia face problems in mastering Mathematical skills, especially in topics such as Algebra and Geometry. This problem is associated with ineffective teaching methods and a lack of student interest in the subject.The Malaysian Ministry of Education (2022) report also found that TVET students' achievement in Mathematics is still low compared to other subjects. This affects students' ability to understand technical concepts that require a strong foundation in Mathematics.

A study by Ahmad Shah Qasemi & Ainol Haryati Ibrahim (2015) .suggests that most TVET students lack confidence in their Mathematics abilities, especially in solving problems involving calculations. This may be due to negative perceptions towards the subject that have been built since primary school.Therefore, there is a need to improve the effectiveness of teaching and learning Mathematics in TVET programs in Malaysia. This can be done by using more innovative and engaging teaching approaches, as well as strengthening students' foundation in Mathematics from an early stage.

Numerous studies have highlighted the persistent challenge of poor mathematical performance among students enrolled in vocational and technical education and training (TVET) programs. This deficiency poses a significant obstacle as mathematical competency is a crucial foundation for success in engineering and technical fields (Niss, 2020). To effectively address this issue, a comprehensive realignment and refocusing of TVET curricula are imperative to cultivate the essential characteristics desired in practicing engineering professionals.

One of the primary objectives of this realignment should be to foster a deeper understanding and appreciation for the practical applications of mathematical concepts in real-world engineering contexts. By establishing clear connections between theoretical principles and their practical implementations, students can develop a more profound motivation to master mathematical skills (Bed Raj Acharya,2017). Furthermore, incorporating problem-based learning strategies and hands-on projects that simulate authentic engineering challenges can enhance students' ability to translate abstract mathematical concepts into tangible solutions (Maarop & Radzi, 2021). Additionally, TVET programs should emphasize the development of critical thinking, problem-solving, and analytical skills, which are indispensable for success in engineering professions. By integrating these essential skills into the curriculum, students can better grasp the significance of mathematics as a powerful tool for understanding and resolving complex engineering problems (Nabie et al., 2021).

In summary, to address the persistent challenge of poor mathematical performance among TVET students and better prepare them for careers in engineering, a comprehensive realignment and refocusing of TVET curricula are crucial. By emphasizing practical applications, incorporating problem-based learning strategies, and fostering critical thinking and analytical skills, TVET programs can effectively promote the characteristics desired in practicing engineering professionals.

## PROBLEM STATEMENT

Technical and Vocational Education and Training (TVET) students in Malaysia consistently demonstrate poor performance in Mathematics. This deficiency hinders their ability to grasp technical concepts crucial for their chosen fields, potentially impacting their future success in engineering and technical professions. The issue stems from ineffective teaching methods, lack of student interest, negative perceptions towards Mathematics, and insufficient emphasis on practical applications of mathematical concepts in real-world engineering contexts. This persistent challenge necessitates a comprehensive realignment of TVET curricula to better prepare students for the mathematical demands of their future careers and to cultivate the essential characteristics desired in practicing engineering professionals.

Therefore, to achieve mathematical competence outcomes, finding or best practice the elements of mathematical competence in real-world practice requires first and foremost attention.

## RESEARCH OBJECTIVE

To identify the essential mathematical skills required for success in various engineering and technical professions.

## RESEARCH QUESTIONS

What the relevant mathematical competencies required for success in various engineering and technical professions?

## IMPORTANCE OF STUDY

The research on improving Mathematics performance among Technical and Vocational Education and Training (TVET) students in Malaysia is crucial for enhancing the quality of TVET education and workforce development in the country. The importance of this research extends beyond the educational sphere, as it directly contributes to developing a highly skilled workforce in technical and engineering fields, which is essential for meeting industry demands and supporting Malaysia's economic growth. Moreover, improving mathematics skills among TVET students is vital for preparing them to adapt to the rapidly evolving technological landscape and the demands of Industry 4.0 (Bed Raj Acharya,2017) (Izrah et al., 2022)( Rashmi Rani et al., 2021)

The study's findings have the potential to significantly impact curriculum reform in TVET programs, particularly in Mathematics education. By ensuring that the curriculum remains relevant and effective, it can better prepare students for their future careers (Natakoji & Wilson, 2018), Moreover, this research contributes to the development of innovative and effective teaching methods for Mathematics in TVET programs. For instance, integrating technology-enhanced learning and problem-based approaches has shown promising results in improving Mathematics performance (Tarzimah & Thamby Subahan, 2010). By addressing challenges in Mathematics performance, this study can play a vital role in stimulating interest in Science, Technology, Engineering, and Mathematics (STEM) fields among students, which is crucial for Malaysia's long-term development in areas of technology and innovation (Ahmad Shah Qasemi & Ainol Haryati Ibrahim, 2015)(Gazali, R. Y. (2016).

In conclusion, this research on improving Mathematics performance in Malaysian TVET holds substantial importance, with implications extending beyond education to workforce development, economic growth, and social progress. By addressing the critical issue of Mathematics performance, it contributes to producing more skilled graduates, meeting industry demands, and enhancing Malaysia's competitiveness in the global knowledge economy. The multifaceted impact of this study highlights its potential to drive significant positive change in the Malaysian education system and broader society.

## METHODOLOGY

To ensure a representative and diverse sample of practicing engineers, irrespective of gender, achievement level, or cultural background, a purposive sampling strategy was adopted (Creswell, 2019). This approach is utilized when researchers aim to select a purposive sample that closely reflects a broader group of cases. The study employed homogeneous sampling, which involves selecting individuals with similar traits or characteristics (Creswell, 2019). The initial step involved identifying a company registered with the Federation of Malaysia Manufacturing (FFM) that produces specific products. An electronic manufacturing company located in Pasir Gudang, Johor, was chosen for this investigation. The manufacturing department of the company, where experienced engineers critically engage in problem-solving activities, was selected for the study. An engineer who demonstrated expertise in mathematical competencies and problem-solving abilities was chosen as the sample for this investigation. The study sample consisted of 5 engineers with a manufacturing engineering background. The nature of work in the engineering department aligned with the study's objective to examine mathematical competencies among engineers in the workplace setting.

Phenomenology is a type of qualitative research that began in the early 1900s. It focuses on how people experience things and has two main approaches: descriptive, which aims to describe experiences, and interpretive, which tries to understand what these experiences mean. Some researchers believe that understanding personal experiences (qualitative research) comes before measuring things (quantitative research). In a phenomenology study about engineers, researchers would try to understand how they use math at work, what this means to them, and when it happens. To do this, they need to use the engineers' own words and describe their experiences accurately. This type of research usually builds ideas from what it finds, uses interviews where people can speak freely, and lets the engineers control the conversation to uncover new information. Phenomenology affects what questions are asked and what kind of information is found. It's more about how people see things rather than just measuring the things themselves. Figure 1 shows the process of how this type of research is conducted.

The data analysis techniques is Phenomenology data analysis techniques. The initial step of the analysis involves horizontalization, which entails identifying specific statements in the transcripts that offer insight into the participants' experiences. These significant statements are extracted from the transcripts and presented in a table, enabling readers to comprehend the diverse perspectives on the phenomenon (Moustakas, 1994).

We compiled verbatim statements from the mentors, which represent unique and non-redundant significant statements. These statements were derived subjectively from the transcripts and comprised complete sentences. We did not attempt to categorize or sequence them in any way. Our objective in this analysis phase was to grasp how individuals perceive the term "Mathematical Competence." By reviewing their statements, we can obtain a more comprehensive understanding of how people experience reinvesting in others. According to Moustakas (1994), the horizon refers to "the grounding or context of the phenomenon that gives it a distinct character." As we examine each horizon and its textural properties, we can gain insight into our own self-awareness and reflections on the experience. Figure 1 is the steps from the beginning of data collection, analyzing the data and until the findings of the study.

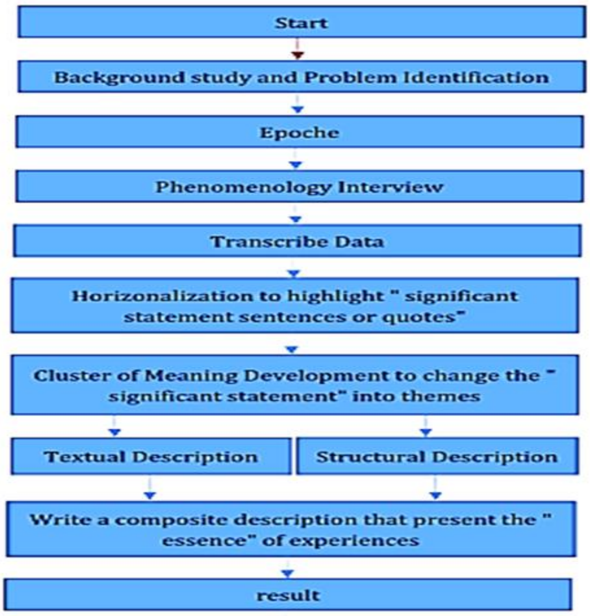


Figure 1: The Flow Chart for Phenomenological Methodology and Analysis

## FINDINGS

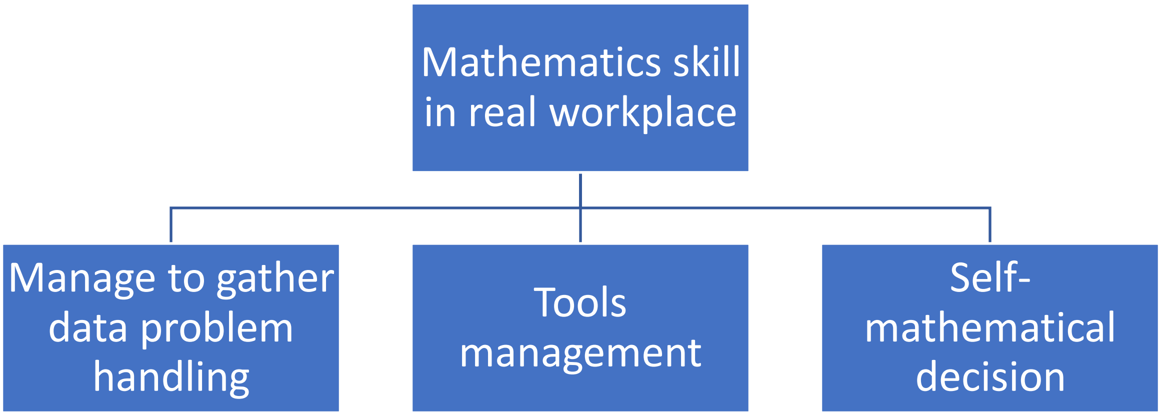


Figure 2: Findings of Mathematical Competancies

Engineering problem-solving is a complex process that relies on several key competencies as figure 2. Findings as figure 2 highlight three crucial aspects: Manage to gather data problem handling, Tools management, and Self-mathematical decision.

### *Manage to Gather Data Problem Handling.*

Engineers must approach problem-solving methodically, gathering comprehensive information before proceeding to solution development. This process involves collecting data from various sources, including stakeholders, subject matter experts, industry reports, and internal company data. As Engineer 1 noted,

"Next, as we gather more information and data, I was sending an email to some departments, such as QC, Production, Warehouse, and Engineering, inviting them to a meeting to discuss problems and data collection."

Engineer 2 explained:

"..........I was plan based on the information I get and try to organise steps to work based on the experience and knowledge and environment available, it is necessary to give me focus on my work........"

*Tools management*

For second skill is Tools management. Proficiency in using both traditional and modern measurement tools is also crucial for engineers. This skill enables accurate analysis of existing and additional data, informed decision-making based on precise measurements, and quality control through comparison of readings or items. Engineer 1 mentioned,

"……. I use tools called calliper to make confirmation data either good data or data that is out of limit…."

Engineer 4 explained:

"…after we completely create the 3D model for our design, we were transforming this 3D model into a 2D drawing view…what I mean is an orthographic drawing…with this orthographic drawing, we were inserting the part dimension for the front view…side view…and also the view from the top…this drawing was be produced for product development by the production site…."

*Self-mathematical Decision*

Thrid is Self-mathematical decision. Engineers employ mathematical calculations to make informed decisions, which involves breaking down complex problems into manageable components and applying mathematical formulas to analyze each component. This approach allows for objective and rational problem-solving, accurate assessment of situations, and reduced risk of errors.

As Engineer 1 stated:

" ... Based on the data trend information in the table data collection, I decided. The problem comes from the RAW part originating from the part supplier…."

Engineer 3 stated:

"... Based on the data and calculations I have provided; this calculation has proven that the machine built has strong strength compared to the cylinder pressure used. ..."

**DISCUSSION**

This discussion is based on 3 findings found.

*Manage to Gather Data Problem Handling*

Engineers take on additional responsibilities or act on their objectives to solve problem-solving tasks. For example, they may be asked to ask questions or express opinions on behalf of others to decide to meet a work objective, and they may be forced to change the data content mathematically. By adding data or scale issues to each item involved, they emphasise how to design to address difficulties. Engineers can suggest many mathematical answers with the inclusion of knowledge or public data. When they have more information, they can get a better picture of what is happening and think about what needs to be done and how to communicate it to others.

Data gathering is the process of obtaining information about a situation or object (van der Aalst, 2014). This information can be used to solve problems or understand the situation better. Data gathering is a critical component of problem solving, as it allows engineers to identify and evaluate the various options available for solving a problem. Engineers play an essential role in both problem solving and data gathering (Rawboon et al., 2021)( Norhakim et al 2023). They need access to all the necessary information in order to find solutions to problems, and they need to collect data in order to understand the situation. By working together, engineers can help ensure that the workplace remains functional and efficient. They are crucial members of any team, and their skills should be utilised as often as possible.

*Tools management*

Engineers are responsible for designing, developing, testing, and supervising the production of various products and systems. Their work is essential in many industries, including transportation, healthcare, manufacturing, and energy production. Many of the challenges that engineers face are related to the design and development process. In order to overcome these challenges, engineers must be able to use their tool-using skills to solve problems.

One of the most important aspects of an engineer's job is the ability to use tools and technology to solve problems (Subbu Nisha, 2018). Engineers must be able to use their tools to create plans, drawings, models, and prototypes. They must also be able to use these tools to test the designs and ensure that they meet the requirements of the product or system. In order to do this, engineers need access to a variety of equipment and software. This includes machines, computers, software programmes, and other devices.

In addition to using tools and technology in their working environment, engineers must also be able to solve problems. It means that they must be able to find solutions to difficult challenges. This is often done by using the tools and technology that they have access to. They may also need to use their skills in Mathematics and Physics in order to solve the problems (Pepin et al., 2021).

Overall, engineers are responsible for a wide range of tasks related to product development. Their tool-using skills are essential in order to overcome the various challenges that they face. These skills are used from the beginning of the process to the end result. This makes them important not only in terms of their work, but also in terms of the products and systems that they create. Thus, engineers are essential members of any team that is working on a project. Mathematical competence: Self-thinking mathematically

*Self-mathematical Decision*

An engineer makes mathematical decisions by using reasoning, data. By using reasoning, the engineer can determine whether the data is valid and can be used to make a decision (Al-Qudah & Hassan, 2017). The engineer can also use self-confidence to make a decision based on the data. If the engineer is not confident in the data, they may use other sources of information to make a decision. By using these three factors, the engineer can make sound mathematical decisions in the workplace.

Engineers use mathematical reasoning to analyse data and make decisions at workplace. They use mathematical models to study and interpret data, and then make decisions based on their findings. Henderson, P. B. (2018) and Sahroni et al (2022) mention, this process of using mathematical reasoning to analyse data and make decisions is essential to the work of engineers. Engineers rely on precise mathematical reasoning when making decisions at work. For example, an engineer might use a model to predict how a new piece of equipment was behave in the field, or to determine the best way to fix a malfunctioning machine.

Therefore, the studies conducted by Niss (2003) and Soheila (2015) have made several key contributions to the field of engineering, fostering a strong understanding of engineering principles and their application in problem-solving. Their views on mathematical reasoning significantly contribute to engineers' ability to make informed decisions at work, enabling them to solve more complex problems and make better decisions overall. This is an essential skill for any engineer

## CONCLUSION

TVET students need to develop a range of skills to be successful in their field. Three of the most important skills are practical problem-solving, technical analysis, and effective communication. Practical problem-solving is the ability to think critically and creatively about technical concepts and apply them to real-world situations (Thompson et al., 2018). Technical analysis involves breaking down complex problems into smaller, more manageable parts and developing strategies to solve them. Effective communication is the ability to convey technical ideas and concepts clearly to others.

In conclusion, the results show that practical competencies are suitable for applying problem-solving in the workplace. Therefore, it is suggested that the focus of technical training for prospective TVET graduates should consider practical competencies, and these competencies should be included as important learning outcomes. In view of that, the National TVET Council (2023) states that the future TVET curriculum should be built around developing skills such as analytical and problem-solving skills rather than teaching content knowledge alone. Furthermore, emphasis should be laid on teaching students about methods to derive solutions rather than giving the solutions (National TVET Council, 2023).

## REFERENSI


Al-Qudah, Y., & Hassan, N. (2017). Bipolar fuzzy soft expert set and its application in decision making. *International Journal of Applied Decision Sciences*, *10*(2), 175–191. https://doi.org/10.1504/IJADS.2017.084310

Ahmad Shah Qasemi & Ainol Haryati Ibrahim. (2015). An Investigation of English Language Needs of Engineering Undergraduates at Jawzjan University. Retrieve from https://icsai.org/procarch/1iclei/1iclei-53.pdf

Bed Raj Acharya. Factors Affecting Difficulties in Learning Mathematics by Mathematics Learners *International Journal of Elementary Education.* Vol. 6, No. 2, 2017, pp. 8-15. doi: 10.11648/j.ijeedu.20170602.11

Creswell, J. W., & Guetterman, T. C. (2019). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. (6th Edition). Pearson Education International.

Economic Planning Unit. (2022). 12th Malaysia Plan (2021-2025).

Gazali, R. Y. (2016). Pembelajaran matematika yang bermakna. Math Didactic: Jurnal Pendidikan Matematika, 2(3), 181–190. https://doi.org/10.33654/math.v2i3.47

Henderson, S., and Broadbridge, P. (2018). Mathematics Education for 21st Century Engineering Students. Final Report. Carrick Institute for Learning and Teaching in Higher Education Ltd., Melbourne.

Ismail, K., Nopiah, Z. M., & Rasul, M. S. (2016). Malaysian teachers' competency in technical vocational education and training: A review. In Proceedings of the Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014) (pp. 59-66). Springer, Singapore.

Izrah, N., Puzi, M., Azli, N. A., Osman, S., & Yusof, Y. M. (2022). Evaluation of Mathematical Competencies among Electrical Engineering Students. In ASEAN Journal of Engineering Education (Vol. 6, Issue 2).

Juandi, D. (2021). Heterogeneity of problem-based learning outcomes for improving mathematical competence: A systematic literature review. Journal of Physics: Conference Series, 1722(1). https://doi.org/10.1088/1742-6596/1722/1/012108

Khardita, D. A., & Agoestanto, A. (2023). Systematic Literature Review: Mathematical Reasoning Ability in Mathematics Learning. Symmetry: Pasundan Journal of Research in Mathematics Learning and Education, 8(1), 23–31. https://doi.org/10.23969/symmetry.v8i1.7632

Ministry of Education Malaysia. (2023). Malaysian Education Development Master Plan 2023-2030.

Maarop, A. H., & Radzi, N. M. (2021). Implementation of problem-based learning in mathematics for engineering students: A systematic literature review. International Journal of Instruction, 14(3), 781-798.

Moustakas, C. (1994). Phenomenological research methods. London, Sage

Nakakoji, Y. & Wilson, R. (2018). First-Year Mathematics and Its Application to Science: Evidence of Transfer of Learning to Physics and Engineering. Educ. Sci. 2018, 8, 8. Pg 1-16.

National TVET Council (2023). Recommendations for future TVET curricula development.

Niss, M. (2020). Mathematical competencies and challenges for the future. In Proceedings of the 14th International Congress on Mathematical Education (pp. 3-18). Springer, Cham.

Niss, M. A. (2003). “Mathematical Competencies and the Learning of Mathematics: The Danish KOM Project”, in A. Gagatsis and S. Papastav2012ridis, (eds.), 3rd 472 Mediterranean Conference on Mathematical Education City: Athens, The Netherlands.

Nabie, M. J., Yusof, N., & Samsudin, M. A. (2021). Enhancing critical thinking skills in technical and vocational education through problem-based learning. Journal of Technical Education and Training, 13(2), 37-48.

Norhakim Sahroni, M., Izrah Mohd Puzi, N., Kamilah Syed Yusof, S., Ismail, Z., Malaysia, T.,& Bahru, J. (2023). Mathematical Competence of Practicing Engineers in Engineering Tasks. In ASEAN Journal of Engineering Education (Vol. 7, Issue 2).

Pepin, B., Biehler, R., & Gueudet, G. (2021). Mathematics in Engineering Education: a Review of the Recent Literature with a View towards Innovative Practices. International Journal of Research in Undergraduate Mathematics Education, 7(2), 163–188. https://doi.org/10.1007/s40753-021-00139-8

Rawboon, K., Yamazaki, A. K., Klomklieng, W., & Thanomsub, W. (2021). Future competencies for three demanding careers of industry 4.0: Robotics engineers, data scientists, and food designers. The Journal of Competency-Based Education, 6(2), 1–12. https://doi.org/10.1002/cbe2.1253

Rashmi Rani, Rajesh Kanna, Amer Abdelaal, & Durai Pon Raj. (2021). Teaching and Learning Engineering Mathematics by Project Based Learning Method. Asean Journal of Engineering Education, 4(1), 52–56. https://doi.org/10.11113/ajee2020.4n1.18

Sahroni, M. N., Ismail, Z., & Syed Yusof, S. K. (2022). Using Phenomenological Approach to Identify Mathematical Competency in Engineering Workplace. Asean Journal of Engineering Education, 6(1), 40–50. https://doi.org/10.11113/ajee2022.6n1.76

Skills Development Department. (2022). Annual Report 2022.

Subbu Nisha, M. & R. V. (2018). Employability Skills : A Review Employability Skills Required at Workplaces. The IUP Journal of Soft Skills, 12(1), 29–38.

Tarzimah, T. & Thamby Subahan, M.M. (2010) Students’ Difficulties in Mathematics Problem-Solving: What do they Say? Procedia Social and Behavioral Sciences 8 (2010) 142–151.

Thompson, C. J., Barber, K., & Bourget, E. M. (2018). Steam (Science, Technology, Engineering, Art, And Mathematics) Education And Teachers’ Pedagogical Discontentment Levels. People: International Journal Of Social Sciences. Https://Doi.Org/10.20319/Pijss.2018.43.496518

Van der Aalst, W. M. P. (2014). Data scientist: The engineer of the future. Proceedings of the I-ESA Conferences, 7, 13–26. https://doi.org/10.1007/978-3-319-04948-9_2