Journal of Sustainable Civil Engineering and Technology
e-ISSN: 2948-4294 | Volume 3 Issue 2 (September 2024), 1-10
https://joscetech.uitm.edu.my
https://doi.org/10.24191/jscet.v3i2.1-10

Analytic Rubrics for the Practical Assessment of Students' Performances in Engineering Survey Course

Adnan Derahman[1], Nur'Ain Mat Yusof [2*], Noorfaizah Hamzah[1]

[1]School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

[2]Centre of Studies, College of Engineering, Universiti Teknologi MARA Pahang Branch, 26400, Bandar Tun Abdul Razak, Jengka, Pahang, Malaysia

*Corresponding author: nurainyusof@uitm.edu.my

Received: 21 May 2024 / Accepted: 02 September 2024 / Published online: 30 September 2024

Abstract

The use of analytic rubrics as an assessment tool has been an integral component of education. In Surveying courses, it is essential to evaluate the psychomotor skills under simulated conditions of actual practise. The main objective of this study is to determine the comparative and efficacy of practical assessment conducted at the diploma and degree levels in the Civil Engineering programme. In order to achieve the objective, implementing rubrics in the continuous assessment of the Surveying courses to facilitate a profound comprehension of physics, mathematics, and engineering principles needs to be executed. Previously, a practical assessment has been conducted in a traditional method which gauges the student performance according to the time records during certain practical tasks given resulting in inadequate assessment tools that failed to capture the psychomotor component of practical assessments effectively. As for methodology, a comparative analysis was conducted to examine the consistency and usefulness of analytic rubrics in assessing the course and program outcomes of Surveying courses at both diploma and degree levels. The analysis aimed to determine the impact of these rubrics on student performance. This comparison should be conducted in order to prevent redundant actions, as it pertains to diploma level students who will be integrated into the degree program. This assessment reveals that most students met all performance criteria at an acceptable level. This indicates that the analytical rubric used for the Practical Test in Surveying courses is adequate and effective as a grading instrument. As for the results, the comprehensive analysis indicates that a significant majority, ranging from 75% to 81%, exhibited commendable performance in achieving the criteria for various Programme Outcomes (PO), particularly in PO4, PO5, PO9, and PO10.

Keywords: Analytic rubric; Practical test; Assessment; Student performance; Engineering survey

1. Introduction

To produce a greater number of market-ready graduates, Education 5.0@UiTM has developed and implemented a variety of course evaluation strategies. The assessment methods are one of the factors that can influence the academic performance of students. However, research into their effect on performance has yielded inconclusive results (Sacristán-Díaz et al., 2016). The main objective of this study is to determine the comparative and efficacy of practical assessment conducted at the diploma and degree levels in the Civil Engineering programme. To achieve the objective, implementing rubrics in the continuous assessment of the Surveying courses to facilitate a profound comprehension of physics, mathematics, and engineering principles needs to be executed.

Assessment is an integral component of education. In Engineering Survey, it is essential to evaluate the psychomotor skills under simulated conditions of actual practise. In practise, two types of rubrics were commonly employed which are holistic rubrics and analytic rubrics. In the past, conventional approaches were unable to explicitly evaluate students in the areas of psychomotor and cognitive abilities. Therefore, the

e-ISSN: 2948-4294 | Volume 3 Issue 2 (September 2024), 1-10
https://joscetech.uitm.edu.my
https://doi.org/10.24191/jscet.v3i2.1-10

assessor's evaluation is restricted solely to task-based (group) activities. Consequently, the assessment marks were not evenly allocated based on the individual students' performance. An evaluation was carried out using a conventional approach that measured student performance based on the time taken to complete certain practical tasks. However, this method proved to be insufficient in accurately assessing the psychomotor aspect of practical assessments. In holistic rubrics, individual performance standards for each criterion are not specified. Allocating a degree of performance is accomplished by assessing performance across all relevant parameters (Chan, 2015). Analytic rubrics provide distinct achievement standards for each criterion so that instructors can evaluate the performance of students on an individual basis (Chan, 2015, Battershill & Ross, 2017). Analytic rubrics tend to have their scales focus on the most important factors associated with performance criteria. Analytic rubrics tend to have their scales focus on the most important factors associated with performance criteria.

Rubrics are assessment tools that have been developed with a description of the expected performance for desired criteria to achieve results. Additionally, it is used to educate and assess the learning outcomes. The uniqueness of this rubric is in its design, which sets it apart from other analytic rubrics utilized in similar courses. It is integrated into the laboratory manual that is distributed to the students. The students possessed a comprehensive understanding of the item and the criteria for its evaluation. The design rubric enables the assessor from the School of Civil Engineering, Universiti Teknologi MARA, Malaysia to systematically apply score rubrics. Assessors may utilise the rubric during any of the common assessment periods, such as during the typical practical sessions, midterm, and final assessments. The assessors instructed the students beforehand on how to use the scoring rubrics. The practical was conducted in groups of no more than five students, who were required to assign grades based on the rubrics, which served as formative feedback. The scores and the assessors' comments served as a means for the students to learn how to improve further. The intended outcome was to reduce errors and improve good practise, with no or minimal negative consequences.

2. Methodology

The primary objective of implementing rubrics in the continuous assessment of the Surveying courses is to facilitate a profound comprehension of physics, mathematics, and engineering principles. These assessment tools are strategically designed not only to evaluate students' understanding but also to cultivate critical thinking skills in the practical application of survey methods and the discernment of appropriate engineering survey equipment.

For a diploma level student, the expectations extend beyond mere application; they are required to proficiently articulate and justify effective communication strategies related to survey engineering activities. Emphasis is placed on addressing uncommon challenges encountered in solving complex problems within the professional domain. Additionally, these students are tasked with efficiently organizing survey equipment for fieldwork in civil engineering projects.

Whereas, at the degree level, the goals are elevated to encompass the ability to independently conduct field surveys using sophisticated tools such as theodolite, level, and modern surveying equipment. A further requirement involves the in-depth analysis of data obtained from specified surveying equipment. The curriculum places a premium on teamwork, expecting students to function effectively both as individuals and as integral members or leaders within diverse teams in the multifaceted, interdisciplinary setting of the course.

During practical assessments, students are not only expected to set up survey apparatus in secure and well-equipped locations but also need to demonstrate their capability to integrate theoretical descriptions and fundamental concepts into the specific practical tests assigned to them. This multifaceted approach aims to instill a comprehensive skill set in students, preparing them for the complex and dynamic challenges inherent in the field of Engineering Survey.

2.1 Instrument Used

The degree level Engineering Survey course (ECG422) is tailored to immerse students in the practical applications of surveying within the realm of Civil Engineering practices. It serves as a comprehensive introduction to surveying equipment, techniques, and analytical methods. Students enrolled in this course gain a thorough understanding of the intricacies involved in surveying tasks, equipping them with the necessary skills to navigate the challenges encountered in Civil Engineering practices.

On the other hand, the diploma level Surveying course (ECG345) provides a holistic approach by encompassing both theoretical underpinnings and hands-on experiences in the discipline. While delving into the theoretical foundations of surveying, students concurrently engage in practical applications, gaining firsthand experience with surveying techniques. The curriculum is strategically designed to seamlessly integrate theoretical knowledge with real-world applications. This dual focus ensures that students not only grasp the theoretical principles of surveying but also acquire the practical skills essential for executing surveying tasks in various professional settings. Overall, this approach aims to cultivate a comprehensive understanding of surveying principles and practices, preparing students to excel in both theoretical analyses and practical applications within the field of surveying.

2.2 Lesson Plan for Surveying Courses

This research undertook the development of one comprehensive rubric designed to assess both learning outcomes and program learning outcomes within the context of the psychomotor domains. The structure of these rubrics is presented as part of a multi-faceted approach to measuring student proficiency in Surveying courses.

Table 1 furnishes a detailed breakdown of the course contents for both degree and diploma level of Surveying courses, offering insight into the curriculum's components. Meanwhile, Table 2 outlines the assessment methodologies employed for these courses, providing a comprehensive overview of the evaluative processes applied.

Table 1. An example of a table

ECG422 – Engineering Survey Contents (Lab)	**ECG345 – Surveying Contents (Lab)**
1 – Linear distance measurement, angle observation, and bearing calculation	1 – Levelling: Profile and Cross Section
2 – Levelling and tacheometry survey	2 – Traversing: Closed Loop Traverse
3 – Traverse by total station and detail survey	3 – Stadia Tacheometric: Topographic Mapping
4 – Setting out road curve or four corner of the building	4 – Setting out: Horizontal Road Curve

Table 2. The assessment method for the courses

Course / Code	**Method of Assessment**	**Domain**
Engineering Survey / ECG422 (Degree level)	30% Practical test 10% Written report 60% Final exam	Psychomotor (30%) Affective (10%) Cognitive (60%)
Surveying / ECG345 (Diploma level)	60% Practical test 10% Lab report 30% Final exam	Psychomotor (60%) Affective (10%) Cognitive (30%)

To ensure a holistic understanding of the curriculum alignment, Table 3 presents the Course Outcomes (CO) and Programme Outcomes (PO) Matrix for both Surveying courses, facilitating a clear visualization of how course outcomes correspond to program learning outcomes.

Table 3. The tabulation of CO-PO Matrix for both Surveying courses

Code	**ECG422**		**ECG345**	
	Course Outcome (CO)	**Programme Outcome (PO)**	**Course Outcome (CO)**	**Programme Outcome (PO)**
CO1	Describe basic fundamentals of engineering survey.	Engineering Knowledge -Apply knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems (PO1)	Describe survey methods and suitable equipment used for engineering surveys.	Apply knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialization to wide practical procedures and Practices (PO1)
CO2	Use theodolite, level and modern surveying equipment for field survey.	Investigation – Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions (PO4)	Justify the effective communication on survey engineering activities	Communicate effectively on well-defined engineering activities with the engineering community and with society at large, by being able to comprehend the work of others, document their work, and give and receive clear instructions. (PO10)
CO3	Analyse data taken from the stated surveying equipment.	Individual and Teamwork - Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings (PO9)	Organize survey equipment for fieldwork in civil engineering projects.	Apply appropriate techniques, resources, and modern engineering and IT tools to well-defined engineering problems, with an awareness of the limitations. (PO5)

The rubric development process unfolded in four distinct phases, each meticulously detailed in subsequent sections of this paper. By systematically addressing both learning outcomes and program learning outcomes and grounding the rubrics in a contextual understanding of the course contents and assessment methodologies, this study establishes a robust foundation for evaluating and enhancing the psychomotor domains in the

Engineering Survey course. The overall approach framework for this study is effectively provided and discussed in a phased manner. Comprehensive explanations are provided for each phase, ranging from Phase 1 to Phase 4.

Phase 1: Analyse and Identify the CO and PO for Chosen Type of Assessment

During this phase, a meticulous mapping process was undertaken to align Course Outcomes (CO) and Program Outcomes (PO) with various types of assessments, including written reports, projects, technical reports, and presentations. It is important to note that the focus of this study was specifically on CO2, and its evaluation was conducted through a practical test. The detailed breakdown in Table 4 illustrates that each Course Outcome was strategically designed to assess a specific learning domain, with a predetermined dominant level of learning.

This strategic alignment of outcomes with assessment types not only provides a structured framework for evaluation but also ensures a targeted approach to measuring student achievement. By concentrating on CO2 and employing a practical test, this study honed in on a specific aspect of the curriculum, allowing for a detailed examination of the corresponding learning domain and its associated dominant level. This nuanced methodology enhances the precision and relevance of the assessment process, contributing to a more comprehensive understanding of student performance.

Table 4. The tabulation of the CO-PO Matrix for both Surveying courses

Code	**ECG422**		**ECG345**	
	CO2	P4	CO3	P5
Practical Test	Use theodolite, level, and modern surveying equipment for field surveys.	Display skills in using a theodolite, level, and modern surveying equipment for field survey.	Justify the effective communication on survey engineering activities.	Organize survey equipment for fieldwork in civil engineering projects.

Phase 2: Identify Related Level of Learning Domain Covered by CO and Criteria by CO and Criteria of the Domain

The formulation of rubric criteria was informed by the alignment of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs), serving as a catalyst for brainstorming and design considerations. Table 3 above, provides a comprehensive dataset, facilitating the assignment of the predominant level within the learning domain. Criteria for each learning domain were meticulously outlined, with a focus on selecting the most crucial elements.

To enhance the precision of the rubric criteria, Bloom's Taxonomy (Bloom, 1956) was employed to assign corresponding levels and keywords for each domain. The ensuing Table 5 enumerates the identified general criteria and their respective levels within the psychomotor learning domain. Notably, the rubric devised for the end-product evaluation primarily gauged the dominant level of learning, identified as Complex Over Response (P5). Additionally, two supplementary levels, namely Guided Response (P3) and Mechanism (P4), were integrated to provide a more comprehensive assessment framework. This meticulous approach ensures a nuanced and thorough evaluation process aligned with the overarching learning objectives.

Journal of Sustainable Civil Engineering and Technology
e-ISSN: 2948-4294 | Volume 3 Issue 2 (September 2024), 1-10
https://joscetech.uitm.edu.my
https://doi.org/10.24191/jscet.v3i2.1-10

Table 5. General criteria and the level of the psychomotor learning domain for each criterion for both Surveying courses

ECG422 (Degree Level) (P4)	***Psychomotor Domain**	**Items/Elements**
	P1	Identify the experiment and its purpose on the given problem statement.
	P2	State the apparatus/instruments required to be used/conducted in the experiment.
	P3	Display how to set up the instrument/equipment/laboratory testing. (Handle the instrument/apparatus/equipment correctly and carefully).
	P4	Demonstrate how to use the equipment/instrument/apparatus with competence and confidence (Note: Student must demonstrate and explain all the steps accordingly).
	P5	Interpretation of Results (type, data, presentation/formula/method).
ECG345 (Diploma Level) (P5)	P1 (Perception)	List and name write apparatus/equipment required to conduct the surveying work.
	P2 (Set)	Readiness to perform work in terms of safety.
	P3a (Guide Response)	Set up the surveying equipment (Preliminary Stage).
	P3b (Guide Response)	Identify the use of survey equipment components (Preliminary stage).
	P4 (Mechanism)	Procedure to conduct the specific engineering activity.
	P5 (Complex Over Response)	Proceed to produce accurate data / important information.

*Level of psychomotor learning domain for both Surveying course

Phase 3: Formulate Rubric by Type of Assessment and Align with Its Approaches

A comprehensive two-dimensional table was crafted to structure the rubric for the end-product evaluation, where the columns represented the performance levels on a scale, and the rows delineated the learning domains and associated criteria, as detailed in Table 5 above. Employing a 5-point Likert scale, ranging from 1 (very poor) to 5 (excellent), this rubric encompassed seven items specifically designed to gauge psychomotor criteria. Each performance level on the scale was strategically associated with nuanced descriptions, meticulously mapped to the criteria, ensuring a precise and discerning evaluation process. This methodological approach not only provides a structured framework for assessment but also ensures clarity and consistency in evaluating student performance in the psychomotor domain.

Phase 4: Validate the Reliability of Rubric

To ascertain the reliability of the rubrics, a rigorous reliability test was conducted employing both Cronbach's Alpha and Intra-Class Coefficient (ICC). Cronbach's Alpha, a widely adopted metric, was utilized to evaluate the internal consistency and reliability of the scale or test items. Simultaneously, the Intra-Class Coefficient (ICC), a measure of Inter-Rater Reliability (IRR) or inter-rater agreement, was employed to assess the degree of consensus among raters, indicating how closely units within the same group resembled each other within a given set (Taylor, 2010).

The evaluation scores assigned by the raters underwent thorough analysis using the Statistical Package for the Social Sciences (SPSS). This comprehensive approach, leveraging both Cronbach's Alpha and ICC, not only ensures a robust assessment of the rubrics' reliability but also provides a multifaceted understanding of both internal consistency and inter-rater agreement, contributing to the overall validity of the assessment framework. The study incorporates reliability tests, specifically Cronbach's Alpha and Intra-Class Coefficient (ICC), to evaluate the internal consistency and inter-rater agreement of the data, so ensuring its dependability. Ensuring the accuracy and credibility of the evaluation outcomes is crucial.

3. Results and Discussion

The study cohort comprised of 36 groups. This study does not focus on the level of intake of the study population. Therefore, the focus of this study is solely on students enrolled in Surveying courses at the diploma and degree levels. Each group consists of about three to four students. 78 students were from the degree level and 63 students were from the diploma level. The distribution of students' performances according to the psychomotor domain is shown in Figure 1. The number of degree students is higher within 70 to 89 marks compared to diploma students. Figure 2 shows the descriptive analysis for each PO. PO5 appears to be the highest mark for the average categories followed by PO4, PO9, and PO10. Under the maximum categories, PO5 also attained the highest marks followed by PO4, PO10, and PO9. Again, PO5 attained the highest marks under minimum categories followed by PO4 and PO9 which share the same marks and followed by PO10. The descriptive analysis of Course Outcome Attainments for both courses is shown in Figure 3. Diploma students perform higher marks in CO2 whereas degree students perform higher marks in CO3. These offered a comprehensive insight into the nuanced aspects of student achievement and competency. The findings are strongly supported by the acquired data and offer significant interpretations that are pertinent to the objectives of this study.

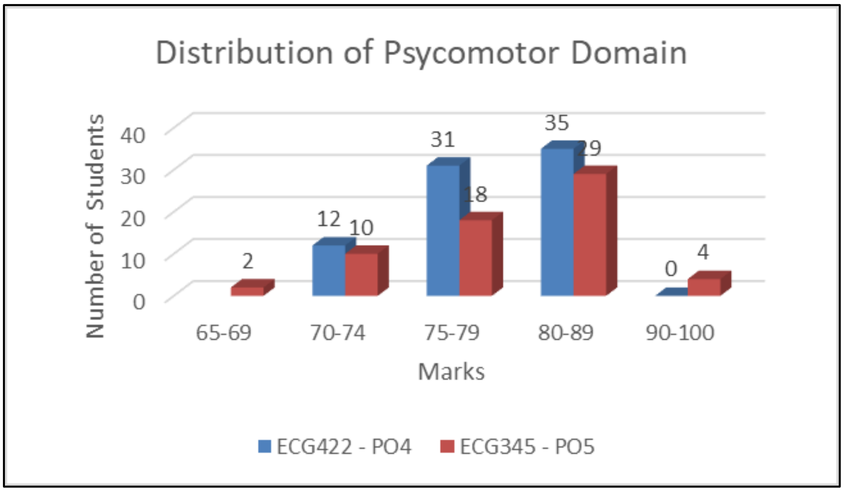

Figure 1. Distribution of students' performances according to the psychomotor domain (ECG422 – CO2, ECG345 – PO10)

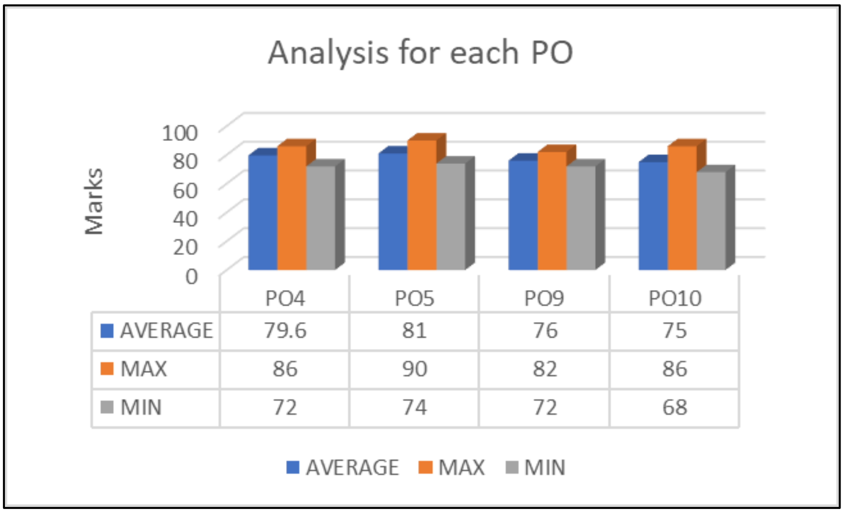

Figure 2. Descriptive analysis for each PO

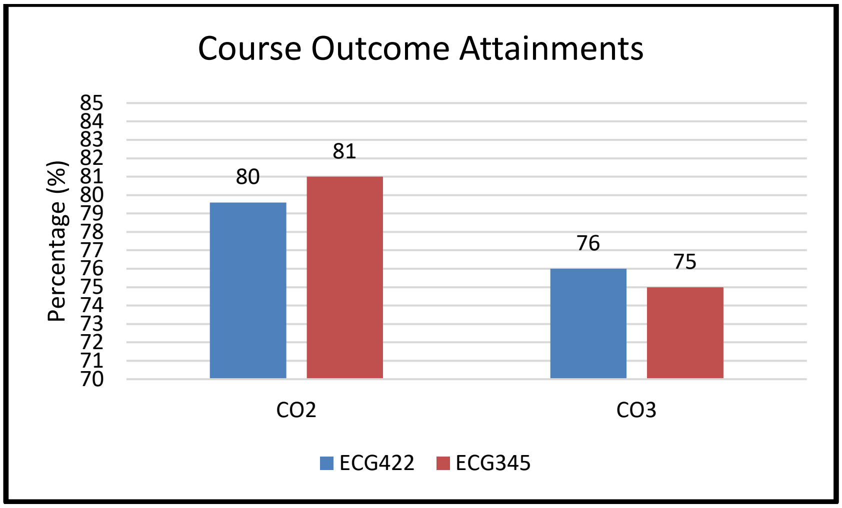

Figure 3. Descriptive analysis for Course Outcome Attainments for both subjects

4. Conclusion

This study reveals a notable proficiency among students in the psychomotor domain, as assessed by employers. The comprehensive analysis indicates that a significant majority, ranging from 75% to 81%, exhibited commendable performance in meeting the criteria for PO4, PO5, PO9, and PO10. This commendable outcome can be attributed to the strategic timing of industrial training, strategically positioned in the final year and semester as per the curriculum design. The students' exposure to industry-relevant skill sets throughout their academic journey, spanning from Semester I to Semester V, facilitated a seamless integration of theoretical knowledge with practical application.

The students actively engaged in laboratory work and hands-on experimental learning, specifically targeting the development of psychomotor skills. The assimilation of knowledge occurred concurrently with the acquisition of practical skills, all of which were subsequently applied during their industrial training. The positive evaluations received from their industrial supervisors substantiate the effectiveness of this experiential learning approach.

In conclusion, the outcomes of this study offer valuable insights for educators, highlighting the pivotal role of hands-on experiences in shaping graduates equipped with the employability skills essential for the demands of various industries particularly in surveying.

In order to improve the usefulness of the study and provide direction for future implementation, the analytic rubrics used in engineering survey courses offer substantial advantages by offering explicit, unbiased standards for evaluating student performance. As a result, this enhances learning outcomes as students comprehend the requirements, promoting a more organized method of acquiring practical skills. In addition, rubrics guarantee uniformity in grading, minimizing subjectivity and prejudice, and matching evaluations with industry benchmarks, enhancing students' readiness for professional application.

It is recommended that educators create comprehensive rubrics, integrate them into the course structure, and utilize them for both peer and self-evaluation. It is crucial to provide training for instructors on the formulation of rubrics and their appropriate utilization, as well as to gather performance data for ongoing enhancement. Working together with experts from the sector helps to keep the rubrics up-to-date and in line with current standards. Additionally, using technology can make the implementation and analysis process more efficient.

Future implementation should involve the pilot testing of rubrics in specific courses, the conduct of longitudinal studies to evaluate their long-term effects, and the exploration of their applicability in many fields. Continual professional development for educators is essential for preserving the efficacy of rubrics, guaranteeing their continued improvement of teaching methods and student learning achievements in engineering education.

Acknowledgments

The authors would like to express their gratitude to the School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, Malaysia for the laboratory expertise and contribution to this research work.

Declaration of Conflicting Interests

All authors declare that they have no conflicts of interest.

References

Battershill, C., & Ross, S. (2017). *Using Digital Humanities in the Classroom: A Practical Introduction for Teachers, Lecturers, and Students*. Bloomsbury Publishing.

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals.* Handbook 1: Cognitive domain. New York: Longman.

Board of Engineer Malaysia (BEM), "*Engineering Technology Accreditation Council Manual*," 2020. http://etac.org.my/wpcontent/uploads/2020/04/Engineering-Technician-Education-Programme-Accreditation-Standard-2020.pdf

Chan CKY (2015). Rubrics for Engineering Education, Engineering Education Enhancement and Research Asia (E3R Asia).

Krebs, R., Rothstein, B., & Roelle, J. (2022). Rubrics enhance accuracy and reduce cognitive load in selfassessment. *Metacognition and Learning*, 17(2), 627–650.

Lipnevich, A. A., Panadero, E., & Calistro, T. (2022). Unravelling the effects of rubrics and exemplars on student writing performance. *Journal of Experimental Psychology: Applied*, 29(1), 136–148. https://doi.org/10.1037/xap0000434

Panadero, E., Alqassab, M., Fernández-Ruiz, J., & Ocampo, J. C. (2023). A systematic review on peer assessment: intrapersonal and interpersonal factors. *Assessment & Evaluation in Higher Education*, 1–23. https://doi.org/10.1080/02602938.2023.2164884

Sacristán-Díaz, M., Garrido-Vega, P., Alfalla-Luque, R., & María-del-Mar, G. Z. (2016). The effects of teaching and assessment methods on academic performance: a study of an Operation Management course. *Innovations in Education and Teaching International*, 53(5), 497-507. https://doi.org/10.1080/14703297.2015.1008546

Taylor, P. (2014). An introduction to intraclass correlation that resolves some common `confusions. Boston, Massachusetts: University of Massachusetts.

Wong, J. Y. H., Chan, M. M. K., Tsang, V. W. Y., Pang, M. T. H., Chan, C. K. Y., Chau, P. H., & Tiwari, A. (2021). Rubric-based debriefing to enhance nursing students' critical thinking via simulation. *BMJ Simulation & Technology Enhanced Learning*, 7(1), 11.

Yan, Z., Lao, H., Panadero, E., Fernández-Castilla, B., Yang, L., & Yang, M. (2022). Effects of self-assessment and peer-assessment interventions on academic performance: A pairwise and network meta-analysis. *Educational Research Review*, 100484. https://doi.org/10.1016/j.edurev.2022.10