Analytic Rubric in Evaluating the Continuous Assessment in Projects of Civil Engineering Undergraduate Students in Dynamics Subject

Nurbaiah Muhammad Noh[1*], Mohd Raizamzamani Md Zain[2], Yazmin Sahol Hamid[3], Ilyani Akmar Abu Bakar[4] and Mazlina Mohamad[5]

[12345]School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
nurbaiah@uitm.edu.my
raizam@uitm.edu.my
yazminsahol@uitm.edu.my
ilyan104@uitm.edu.my
mazlinamohamad@uitm.edu.my
[*]Corresponding Author

https://doi.org/

Received: 23 June 2021
Accepted: 25 September 2021
Date Published Online: 31 October 2021
Published: 31 October 2021

Abstract: This paper presents the assessment of a continuous assessment in a project for the Dynamics subject using an analytic rubric. Dynamics subject should improve the ability of students to evaluate and solve problems using well-understood basic concepts implemented in a simple logical manner. It focuses on the proper interpretation and application of the concepts of mechanics to the solution of engineering problems. To achieve the objective of being able to examine the issue of mechanics, students were asked to prepare a poster that must consist of the real-life application of dynamics, which they must incorporate in the sense of their poster the definition plus the use of basic fundamental principles. An analytic rubric was used as a scaffold in the evaluation of the continuous assessment of undergraduate students of civil engineering in the Dynamics subject. The continuous assessment referred to was the evaluation of a project called 'Poster Dynamics in Life.' Using analytic rubrics, lecturers in this engineering subject (Dynamics) may specifically list evaluation criteria to improve the synchronization of learning, instruction, and assessment. Besides, students may then use the rubric to organize their assigned project, describe goals, define and concentrate efforts where appropriate, identify concerns relevant to the project, and control the process in an attempt to construct a high-quality project. The results from this assessment show that most of the students achieved all the performance criteria at an acceptable level.

Keywords: Undergraduates, Program outcomes, Dynamics subject, Assessment, Rubrics

1. Introduction

Generally, the word 'rubric' has multiple definitions and conveys a variety of responses from practitioners (Popham, 1997, Malini Reddy & Heidi Andrade, 2010, Dawson, 2017). Rubrics may contain comprehensive grading logic, with numbers and even formulas; they may, alternatively, have no numbers and indicate a wide range of quality levels (Sadler, 2009, Prins et al., 2017). Chan (2015) stated that the rubrics were defined as a scoring or grading method used to assess a students' achievement and learning across a set of criteria and objectives. Normally, in higher education, the scoring rubrics are used for various types of performance assessment of the students (Jonsson & Svingby, 2007, Schoepp et al., 2018). In performance assessment, the implementation of the scoring rubric may increase scoring consistency (Bishop, 2012), assist valid judgment of complex abilities, and promote learning (Jonsson & Svingby, 2007, Sáiz Manzanares et al., 2015). The best scoring rubric is developed based on the professional judgment of the academician.

Two types of rubrics were widely used in practice, i.e. holistic rubrics and analytic rubrics. Holistic rubrics do not list individual performance standards for each criterion. Allocating a degree of performance is achieved by evaluating performance across various parameters as a whole (Chan, 2015). Analytic rubrics provide different standards of achievement for each criterion so that the lecturers can measure the performance of the students on a case-by-case basis (Chan, 2015, Battershill & Ross, 2017). The scales of the analytic rubrics typically concentrate on essential dimensions relevant to performance criteria.

Increasing emphasis on formative assessment has greatly contributed to a transition towards the use of rubrics in higher education, as they concentrate on the quality of students' work criteria (Susan, 2013, Andrade & Heritage, 2017). Through the use of scoring rubrics allows students to gain a clearer understanding of what has been evaluated, what criteria grades are focused on, and what standards are supposed to be expected (Sáiz Manzanares et al., 2015, Ragupathi, 2020). Panadero and Jonsson (2013) performed a meta-analysis of the rubric research to explore ways in which the rubrics formatively promote improved students' achievement and which variables influence the impact of using the rubrics. Concerning the ability to positively affect students' performance, the researchers have revealed that the rubrics help boost self-efficacy, reduce students' uncertainty so they know how they will be measured, reduce overthinking, and assist students in reviewing their tasks (Andrade & Heritage, 2017).

In this study, the analytic rubric was used as scaffolds in the evaluation of the continuous assessment of civil engineering undergraduate students in Dynamics subject. The continuous assessment referred to was the assessment of the project called 'Poster Dynamics in Life'. This rubric has been used as a tool for defining and transmitting project requirements to students. Besides, lecturers used this as a score sheet to measure student projects fairly, efficiently and consistently.

2. Methodology

The aim of these rubrics in regards to the continuous assessment of the project in Dynamics subject is to provide a deeper understanding of physics, mathematics, and engineering. The rubrics also encourage the critical thinking skills of students in the application and relationship of physics to engineering issues and daily life. Undergraduate students are also expected to select, define, evaluate and explain a variety of issues or methods that are seldom encountered to solve the complex problems of the real situation and then equate them with the basic concepts they have studied in Dynamics. Students are expected to prepare a poster that must consist of the real-life application of dynamics, which must be incorporated by the definition plus the use of fundamental concepts in the sense of their poster.

2.1 Participants

This research encompassed the selection of 533 students who took a course in Dynamics within the first year of their degree program in Civil Engineering at Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia. Five lecturers participated, who taught a total of twenty different online classes.

2.2 Instruments

2.2.1 Lesson Plan for the Dynamics course

Dynamics is a subdivision of mechanics of bodies and deals with bodies in motion. The lesson plans for the Dynamics course entailed six (6) topics. Topic 1: Kinematics of Particles; Topic 2: Kinetics of Particles; Topic 3: Kinematics of Rigid Bodies; Topic 4: Plane Motion of Rigid Bodies (Forces and Acceleration); Topic 5: Plane Motion of Rigid Bodies (Energy and Impulse Methods) and Topic 6: Vibration. Details of the course content were displayed in Table 1.

The course was administered through a range of teaching methods, including lectures and tutorials. They were designed to allow students to acquire the attributes of the civil engineer envisaged by the faculty as highlighted in the Programme Outcomes (POs). Assessments of students' achievement of the Program Outcomes (POs) and Course Outcomes (COs) as shown in Table 2 were carried out through tests, assignments, a project, and final examinations.

Table 1. Details of the course contents for Dynamics

Topic	Contents (Themes)
1	**TOPIC 1: Kinematics of Particles** Rectilinear motion of particles, Motion of several particles, The curvilinear motion of particles
2	**TOPIC 2: Kinetics of Particles** Newton's Law of Motion, Linear Momentum, Angular momentum, Energy and momentum methods
3	**TOPIC 3: Kinematics of rigid Bodies** Translation, Rotation of a rigid body about a fixed axis, General plane motion
4	**TOPIC 4: Plane Motion of rigid Bodies – Forces and Accelerations** Equation of motion of rigid bodies, Angular momentum of a rigid body in plane motion, D' Alembert Principle
5	**TOPIC 5: Plane Motion of rigid Bodies – Work Energy Method, and Impulse and Momentum Method** Principle of work and energy, Conservation of energy, Principle of impulse and momentum, Conservation of angular momentum
6	**TOPIC 6: Vibrations** Simple harmonic motion; Simple pendulum, Free vibrations of rigid bodies', Conservation of energy

Table 2. CO-PO Matrix for Dynamics Course

Course Outcomes (COs) At the end of this course, the students should be able to:	**Addressing Program Outcomes (POs)**
CO1: Apply the principles of mechanics in solving engineering problems.	PO1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
CO2: Evaluate engineering problems using the basic principle of dynamics systematically and logically.	PO2: Identity, formulate, research literature and analyze complex civil engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

This course was evaluated based on 40 percent of the coursework (test, assignment, and project) and 60 percent of the final examination. To ensure consistency in the evaluation of the achievement of the course outcomes, performance assessment criteria (rubrics) have been incorporated in their continuous assessment. The continuous assessment referred to this was the assessment of the project called 'Poster Dynamics in Life'.

2.2.2 Assessment method

As part of their course work, these students ought to construct a poster that encapsulates the important concepts of one of the themes in their Dynamics course and exemplifies the most important aspects that need to be understood whilst using the theory to solve problems. They were encouraged to include pictures or diagrams to help visualize how the concept being applied to the analysis of structures as well as the relationship between mathematical explanations and actual structures. The project would be an excellent platform for implementing what students have learned from the course and for exposing them to research. One of the topics listed in Table 1 has been allocated to students and one application must be selected from the real-life situations in the vicinity of the students' environment or from the problems that arise as an example of the actual application in the industry.

2.3 The sequence of the rubric

An analytic rubric assessed the knowledge of undergraduate students who took a course in Dynamics within the first year of their Civil Engineering degree program in Civil Engineering about Topics 1 to 6. These rubrics were being used by the students to measure their learning. An excerpt from the summary description of the project was given as on the following sub-topics. Table 3 provides an example of the rubrics for the Dynamics course addressed in the project evaluation.

2.3.1 Contents

The contents in the rubrics for assessing project in Dynamics subject were characterized as follows:

a) Project title: Based on Topics 1 to 6.
b) Define the problem (Problem Statement): Explanation of issues, questions of analysis, or problem identification. (CO1-PO1)
c) Explain and describe the chosen topic (Theoretical Background): General overview of the project. Introduction of the selected theoretical background and fundamental concept. (CO1-PO1)
d) Establish criteria for solving the solution (Method of Solution): How did you come out with a possible solution? Use mathematical calculations to prove your theory. Consider alternate solutions. Include specific suggestions and strategies that enable you to solve the assigned problems more efficiently. (CO1-PO1)
e) Evaluate the problem (Problem Analysis & Discussion): Analyze what was observed and its impact and discuss or criticize the chosen solution. (CO2-PO2)
f) Summary (Conclusion & Recommendation): Summarize the key findings, outcomes, or information obtained from your project and make recommendations for future work. (CO2-PO2)
g) Content/organization. How the detail's design and information are displayed in the project. (CO2-PO2)

2.3.2 Design

The design components of the poster were given as follows:

a) Work individually to construct a poster.
b) The poster must be in Portrait orientation.
c) Posters may contain photographs, figures, and tables.
d) Students need to use their creative approach for the layout design of their poster. However, essential headings, as mentioned in the content section such as Problem Statement, Theoretical Background, Method of Solution, Problem Analysis and Discussion, and Conclusion and Recommendations, must be present in their poster.

Table 3. Assessment form of Project in Dynamics subject

	Performance Criteria				
Technical Dimensions/Weight	**Developing (1–2 marks)**	**Good (3-5 marks)**	**Excellent (6-7 marks)**	**Superior (8-10 marks)**	**Score**
PROBLEM IDENTIFICATION (20%) (CO1-PO1) WP1, Depth of knowledge (C1-C2), Define	Able to define the problem broadly to be solved with general relevant facts or information**.**	Able to define moderately the problem to be solved with acceptable facts and gathering relevant information**.**	Able to define the problem substantially to be solved by thinking through few validated facts and relevant information**.**	Able to define precisely the problem to be solved by thinking through validated facts and relevant information.	
THEORETICAL BACKGROUND (20%) (CO1-PO1) Define terms and appropriate concepts WP1, Depth of knowledge (C1-C2), Address (C3-C4) Demonstrate, Explain	Fail to address adequately theoretical explanations.	Address limited explanation of theoretical explanations. Not all the steps of the process have been clearly explained.	Adequately demonstrate theoretical explanations. All steps of the process have been thoroughly explained.	Sufficiently demonstrate in-depth research and analysis. Process of steps explanations are expanded beyond simple definitions.	
GENERATE MULTIPLE SOLUTION (CO1-PO1) (20%) WP1, Depth of knowledge (C1-C4), Select, Solving WP4, Familiarity of issues (C5-C6), Justify, Compare	Select one infrequent encountered issue or approach for solving the problem that does not apply within a specific context.	Select two infrequent encountered issues or approach for solving the problem that does apply within a specific context.	Select and justify at least two infrequent encountered issues or approaches for solving the problem, only some of which apply within a specific context.	Select, justify and compare multiple infrequent encountered issues or approaches for solving the problem that applies within a specific context.	
PROBLEM ANALYSIS (20%) (CO2-PO2) WP3, Depth of analysis required (C3-C4), Calculation (C5-C6), Evaluation,	Calculation of solutions is superficial (for example, contains cursory, surface-level explanation) and includes the following: considers the history of the problem, logic/reasoning, examines the feasibility	Calculation of solutions is brief (for example, explanation lacks depth) and includes the following: considers the history of the problem, logic/reasoning, examines the feasibility of the solution	Evaluation of solutions is adequate (for example, contains thorough explanation) and includes the following: considers the history of the problem, reviews logic/reasoning, examines the feasibility of the solution, and weighs impacts of solution.	Evaluation of solutions is in-depth and elegant (for example, contains thorough and insightful explanation) and includes, deeply and thoroughly, all of the following: considers the history of the problem, reviews logic/reasoning, examines	

Review, Impacts	of the solution			the feasibility of the solution, and weighs impacts of solution.
SUMMARY (10%) **(CO2-PO2)** WP3, Depth of analysis required **Transfer Knowledge** Adopts and applies skills. Abilities, theories, or methodologies gained in one situation or discipline to new situations C1-C2), Uses (C3-C4), Adapt and Apply	Uses, in a primary way, skills, abilities, theories, or methodologies gained in own discipline or experience to interpret an issue.	Uses skills, abilities, theories, or methodologies gained from multiple disciplines to interpret an issue	Adapts and applies skills, abilities, theories, or methodologies gained from multiple disciplines to interpret or explore issues.	Adapts and applies, independently, skills, abilities, theories, or methodologies gained from multiple disciplines to interpret a problematic issue or explore complex issues in original ways
CONTENT / ORGANIZATION (10%) **(CO2-PO2)** (C1-C2), Design (C3-C4), Executed	The Design of the content lacks a central theme, a clear point of view and the logical consequence of information. Much of supporting information in the poster is irrelevant to the overall message. Information is incomplete and incorrect.	The Design of the content does not present a clearly stated theme, is vague, and some of supporting information does not seem to fit the main idea or appears as a disconnected series of the scene with no main unifying idea.	Information is executed as a connected theme with accurate, current supporting information that contributes to understanding the main project idea. Details are logical and persuasive information is effectively used. The content includes a clear point of view with a progression of ideas and supporting information.	The information executed a clear statement of purpose or theme and is creative, compelling and clearly written. A wide variety of supporting information in the poster contributes to understanding the main project of idea. Events and messages are presented in a logical order.
TOTAL 100%		**Technical / Content Criteria**		

Note:
C1 represents Bloom Learning Level 1 : Uses, Select
C2 denotes Bloom Learning Level 2 : Define, Address
C3 represents Bloom Learning Level 3 : Demonstrate, Explain
C4 denotes Bloom Learning Level 4 : Calculate, Execute, Solve
C5 represents Bloom Learning Level 5 : Justify, Compare,
C6 denotes Bloom Learning Level 6 : Evaluate, Review, Impacts

2.4 Tackling Complex Engineering Problems in Dynamics course through Project Evaluation

The solution of complex engineering problems need not be restricted to the final examination. Assignments or projects could also provide a solution to complex engineering problems, as has already been presented in this Dynamics subject. The project assessment rubric was matched with the corresponding Knowledge Profile (WK) and Complex Engineering Problem attributes (WP) as shown in Tables 4 and 5.

Table 4. Mapping of graduate attributes (WA) & knowledge profiles (WK)

Project														
Level of Bloom Taxanomy	**GRADUATE ATTRIBUTES (WA) & KNOWLEDGE PROFILES (WK)**													
	WA1				**WA2**				**WA 3**	**WA 4**	**WA 5**	**WA 6**	**WA 7**	**WA 8**
	WK 1	**WK 2**	**WK 3**	**WK 4**	**WK 1**	**WK 2**	**WK 3**	**WK 7**	**WK 5**	**WK 8**	**WK 6**	**WK 7**	**WK 7**	**WK 7**
	Natural Sciences	**Mathematic**	**Engineering Fundamental**	**Speacialist Knowledge**	**Natural Sciences**	**Mathematic**	**Engineering Fundamental**	**Speacialist Knowledge**	**Engineering Design**	**Research Literature**	**Engineering Practice**	**Comprehension**	**Comprehension**	**Comprehension**
C5-C6	√	√	√											

Note: C5 represents Bloom Learning Level 5 : Justify, Compare,
C6 denotes Bloom Learning Level 6 : Evaluate, Review, Impacts

Table 5. Mapping of complex engineering problem solving (relevant WPs)

Project											
Level of Bloom Taxonomy	**COMPLEX PROBLEM SOLVING (CP) (RELEVANT WPs)**										
	WP1 Depth Of Knowledge					**WP2**	**WP3**	**WP4**	**WP5**	**WP6**	**WP7**
	Wk3 - Engineering	**Wk4 - Engineering Specialist**	**Wk5 - Engineering Design**	**Wk6 - Engineering Practice**	**Wk8 - Literature**	**Range Of Conflicting Requirement**	**Depth Of Analysis Required**	**Familiarity Of Issues**	**Extensive Applicable Codes**	**Extend Of Stakeholders Involvement & Conflicting Requirement**	**Interdependence**
C5-C6	√						√	√			

Note: C5 represents Bloom Learning Level 5 : Justify, Compare,
C6 denotes Bloom Learning Level 6 : Evaluate, Review, Impacts

Bloom Taxonomy assists Dynamics lecturers in the creation of project assessment rubrics drawn from various cognitive levels as shown in Table 3. Such Bloom taxonomy were among the heterogeneous platforms in engineering education to design assessment as they provide complex engineering problem (complexity) and higher-level abilities as mapped in Tables 5 and 6. Based on the findings in Figures 4 and 5, which address the complex engineering problem (C5-C6), these groups of students show that they are capable of selecting and explaining at least two infrequent problems or approaches to alleviate the problem, only some of which are applicable in a specific context. And, in terms of generate multiple solution, only half of the students are capable of explaining and applying skills, abilities, theories or methodologies derived from variety of disciplines to perceive or stimulate discussion. However, some students are capable of delivering an in-depth and informative clarification, analysing some of the logic, evaluating the feasibility of the solution, and weighing the effect of the solution.

3 Results and Discussion

In this study, 533 students were selected from 20 groups of the Dynamics course in Civil Engineering. A total of four technical dimensions were set on each performance criteria to evaluate the assessment (project) of the students. Each sample was analyzed for the following performance criteria: Problem Identification (PI), Theoretical Background (TB), Generate Multiple Solution (GMS), Problem Analysis (PA), Summary (S), and Content/Organization (C/O). Performance criteria (PC) of PI, TB, GMS, and PA, which addressed CO1PO1, were critically measured because is related to basic engineering skills for students to identify, demonstrate, formulate and solve engineering problems. This is followed by S and C/O, addressed CO2PO2, which relate to summarizing the key findings, outcomes, or information and organizing the overall project. Descriptive statistics have been calculated which include the mean, median, mode, and standard deviation, as well as the frequency statistics for each performance criteria.

3.1. Measures of Central Tendency of the Continuous Assessment (Project) of Civil Engineering Undergraduate Students in Dynamics Subject

Table 6 summarizes the results of calculated statistics by six performance criteria used as indicators for the continuous assessment (the project) of Civil Engineering Undergraduate Students in Dynamics Subject. The outcome is measured in four technical dimensions that include developing, good, excellent, and superior. Results shown in Table 6 indicate that the mean scores and standard deviations for the GMS, PA, S, and C/O from four categories of the technical dimension are insignificant statistically differences. This implies that the students' performance in classification depicted the different trend for the four PC. Results also show that the overall performance for all PC is below average. A similar trend has been observed for CO2PO2 outcome, which is for S and C/O.

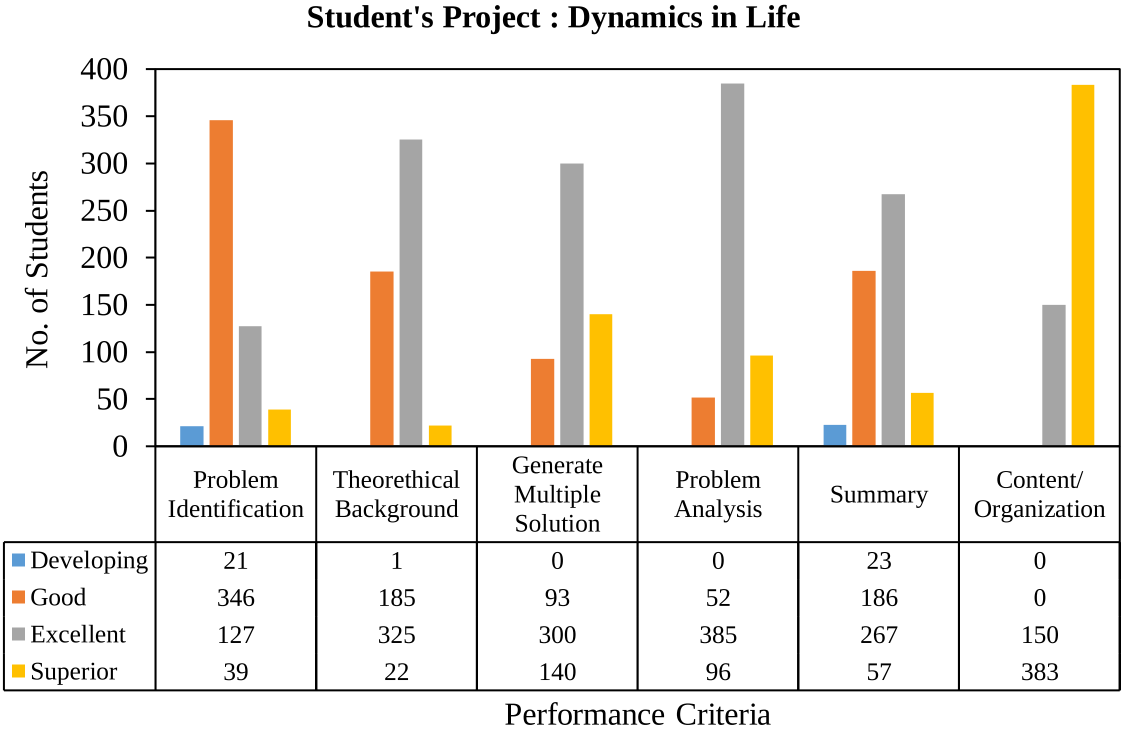
3.2 Measures of Frequency of the Continuous Assessment (Project) of Civil Engineering Undergraduate Students in Dynamics Subject

The summary in Figure 1 is the result of measure frequency conducted for all PC concerning four technical dimensions. The result also can be obtained in Table 6. Concerning the outcome measurement frequency of the PC based on four technical dimensions, C/O has the greatest frequency at a "Superior" level. This is because the students could execute a clear statement of purpose or theme and were creative, compelling, and written with a wide variety of supporting information in the poster contributes to understanding the main project of the idea. Besides, the students managed to present events and messages in a logical order. However, TB has the lowest frequency at a superior level that shows most students were still unable to sufficiently demonstrate in-depth research and analysis as well as to expand the explanation of the process steps beyond simple definitions. This is not surprising considering that many first-year college students have little interest in understanding the theoretical background. They would rather memorize terms or meanings, as well as the steps required to solve a problem. It was agreed to address concept-related questions to increase students' interest in understanding the basic concept as well as their ability to clarify the process steps beyond simple definitions.

In general, it can be observed that most of the students were at a "Good" level in identifying the problem which shows that the students needed to improve their ability to define precisely the problem to be solved by thinking through validated facts and relevant information. For other PC, the students had achieved their performance at an "Excellent" level. This indicates that most of the students were able to adequately apply a depth of knowledge and analysis in the Dynamics study.

Table 6. Descriptive Statistics for the Continuous Assessment (Project) of Civil Engineering Undergraduate Students in Dynamics Subject

Performance Criteria	Assessment	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage	Mean	Mode	Median	Std. Dev
Problem Identification	Developing	21	3.9%	21	3.9%	9.917	10	10	3.047
	Good	346	64.9%	367	68.9%				
	Excellent	127	23.8%	494	92.7%				
	Superior	39	7.3%	533	100.0%				
Theoretical Background	Developing	1	0.2%	1	0.2%	11.542	12	12	1.935
	Good	185	34.7%	186	34.9%				
	Excellent	325	61.0%	511	95.9%				
	Superior	22	4.1%	533	100.0%				
Generate Multiple Solution	Developing	0	0.0%	0	0.0%	13.475	14	14	2.427
	Good	93	17.4%	93	17.4%				
	Excellent	300	56.3%	393	73.7%				
	Superior	140	26.3%	533	100.0%				
Problem Analysis	Developing	0	0.0%	0	0.0%	13.182	12	12	2.072
	Good	52	9.8%	52	9.8%				
	Excellent	385	72.2%	437	82.0%				
	Superior	96	18.0%	533	100.0%				
Summary	Developing	23	4.3%	23	4.3%	5.700	6	6	1.674
	Good	186	34.9%	209	39.2%				
	Excellent	267	50.1%	476	89.3%				
	Superior	57	10.7%	533	100.0%				
Content/ Organization	Developing	0	0.0%	0	0.0%	7.638	8	8	0.627
	Good	0	0.0%	0	0.0%				
	Excellent	150	28.1%	150	28.1%				
	Superior	383	71.9%	533	100.0%				



	Problem Identification	Theorethical Background	Generate Multiple Solution	Problem Analysis	Summary	Content/ Organization
Developing	21	1	0	0	23	0
Good	346	185	93	52	186	0
Excellent	127	325	300	385	267	150
Superior	39	22	140	96	57	383

Fig. 1 Continuous Assessment of Dynamic Project (Dynamic in Life) measured from PI, TB, GMS, PA, S, and C/O.

Figure 2 shows the result of the problem identification criteria assessment. The highest result was obtained for the "Good" technical dimension at 64.9%. The lowest value was obtained for the "Developing" at 3.94%, followed by "Superior" and "Excellent" at 7.3% and 23.83%, respectively. Overall, the result indicates that most of the students can define moderately the problem to be solved with acceptable facts and gathering relevant information. This is because they had not been exposed to real-life problems and therefore had a limited understanding of them. This can be improved by exposing the students to solve more problems that are related to the real issue. During their final year of study, they may also engage in industrial training to enhance their skills and understanding.

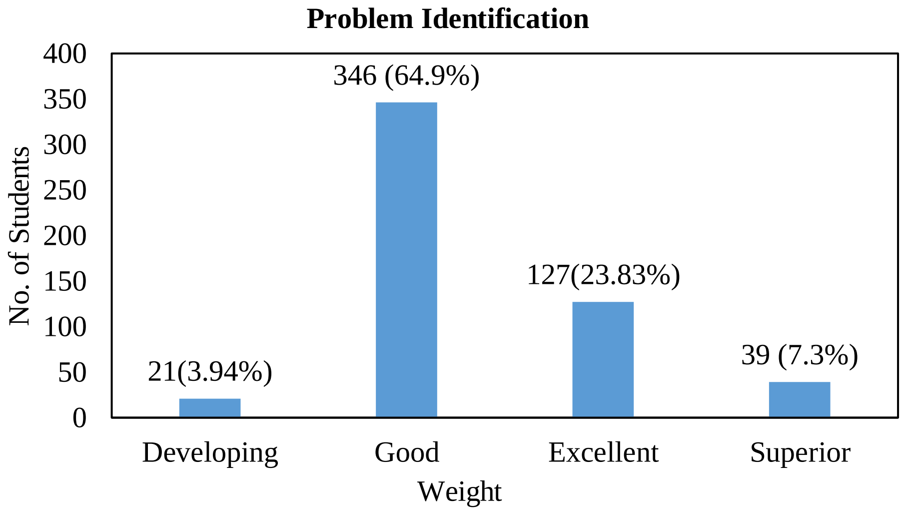


Fig. 2 The problem identification criteria assessment.

The performance of students in terms of theoretical background criteria, as shown in Figure 3, indicates that most students adequately demonstrated theoretical explanations and that all steps of the process were completely explained. This displays the "Excellent" level of achievement in 61% of students. An estimated 34.7% of them assessed at the "Good" grade, which was capable of explaining a minimal description of theoretical approaches, and not as many steps in the process had been clearly explained. Moreover, only 4.1% of students were capable of sufficiently demonstrating in-depth research and analysis with excellent explanation for process steps. While less than 1% of the students failed to address adequately theoretical explanations.

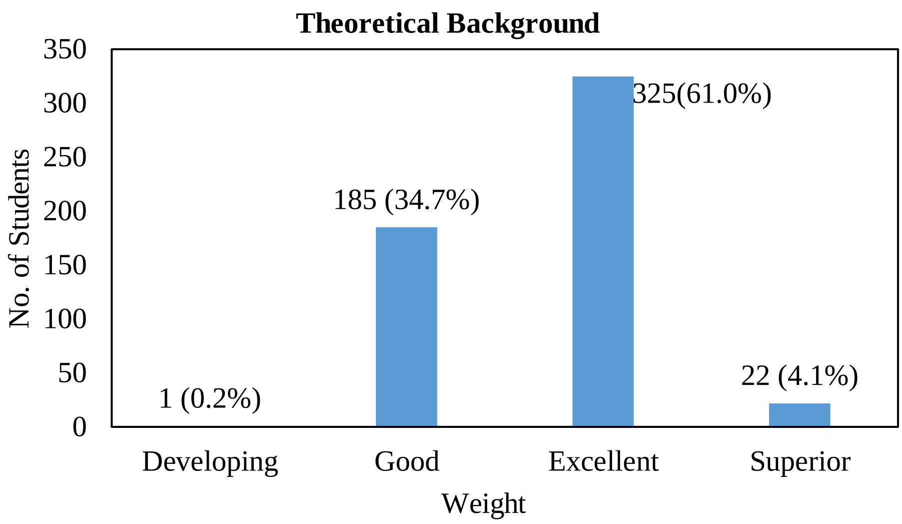


Fig. 3 The theoretical background criteria assessment.

In Figure 4, approximately 56.3% of students with an "Excellent" grade were recorded. This group of students demonstrated that they were capable to select and describe at least two infrequent problems or approaches encountered to solve the problem, in which only some were applicable in a specific sense. However, 26.3 % of students managed to get a "Superior" grade, while the remaining 17.4% scored for a "Good" grade.

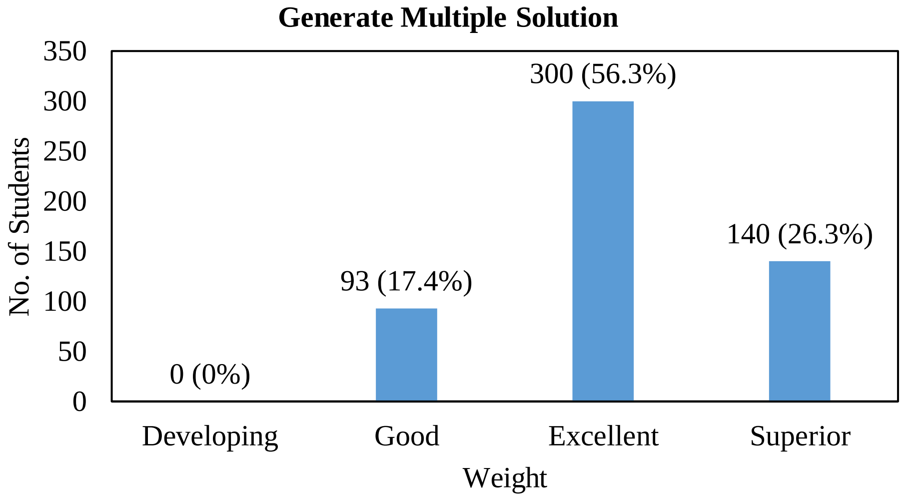


Fig. 4 The Generate Multiple Solution criteria assessments.

As shown in Figure 5, a similar pattern is presented as in Figure 4 for the frequency result of PA criteria. The highest grade that most students scored was “Excellent” with 72.2%. About 18.0% of students scored for “Superior” grade, less than 10% of the students got scores for “Good” grade and, no student gave a superficial solution, such as contains a cursory, surface-level explanation.

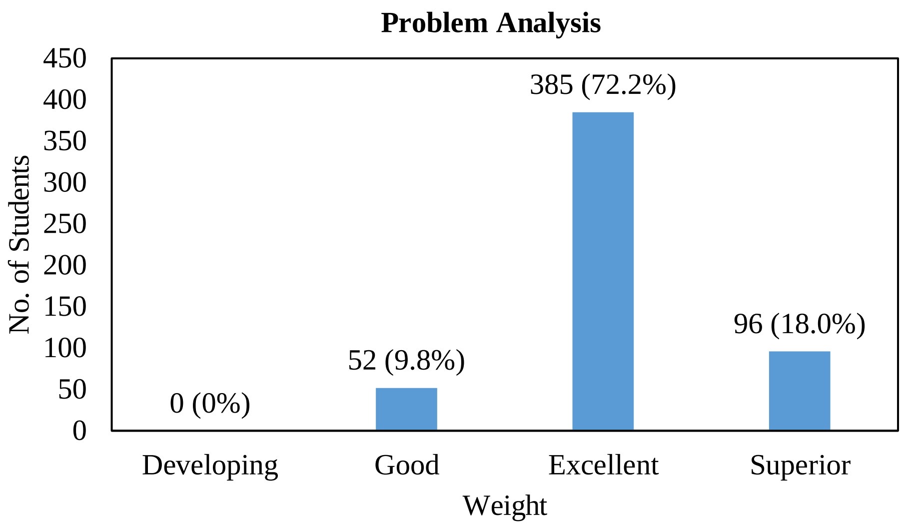


Fig. 5 The problem analysis criteria assessments.

The result of the S-criteria frequency measure is shown in Figure 6. This has also been reported that the majority of the students have attained an "Excellent" grade for S criteria which reached more than 50%. However, only 4.3%, 10.7%, and 24.9% of the students obtained “Developing”, “Superior”, and “Good” grades, respectively. These results show that only half of the students were capable to adapt and apply skills, abilities, theories, or methodologies gained from multiple disciplines to interpret or explore issues with supervision. This outcome is directly connected to the student's ability to understand the theoretical background and recognize the problem. Students who did not grasp the basic concept and were unable to identify specific problems may have difficulty identifying the accurate concepts or principles to apply and interpreting the overall issues.

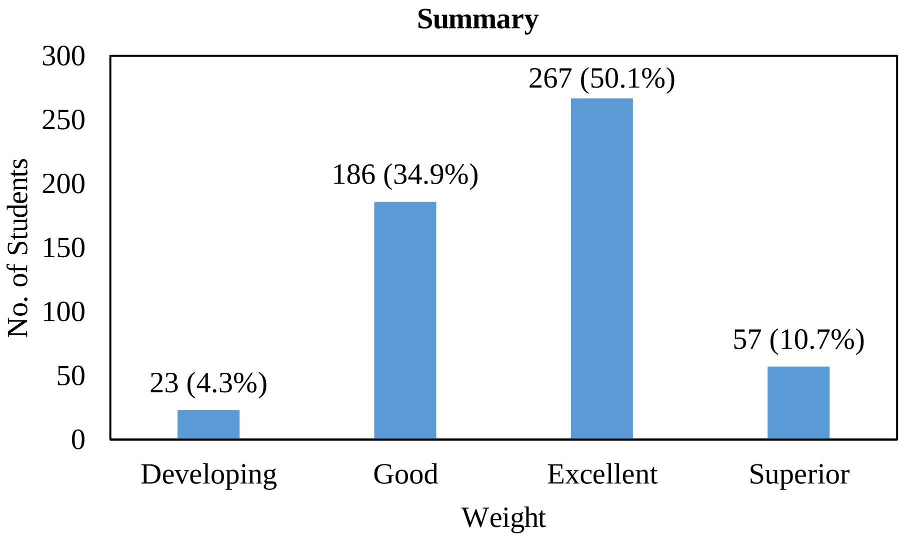


Fig. 6 The summary criteria assessments.

One observation that can be made from Figure 7 is that the highest percentage of students' score based on the C/O criteria was the “Superior” grade with 71.9%. Followed by 28.1% for the “Excellent” grade, and 0% for both “Developing” and “Good” grade. This result shows a different pattern from the previous criteria. In general, this result indicates the students had no issues in designing the materials of the project clearly, imaginatively, impressively, and by well written, as well as with an objective or subject. Besides, most of the students provided a wide variety of supporting information in the poster contributing to the understanding of the main project idea. Furthermore, the events and messages were presented in logical order.

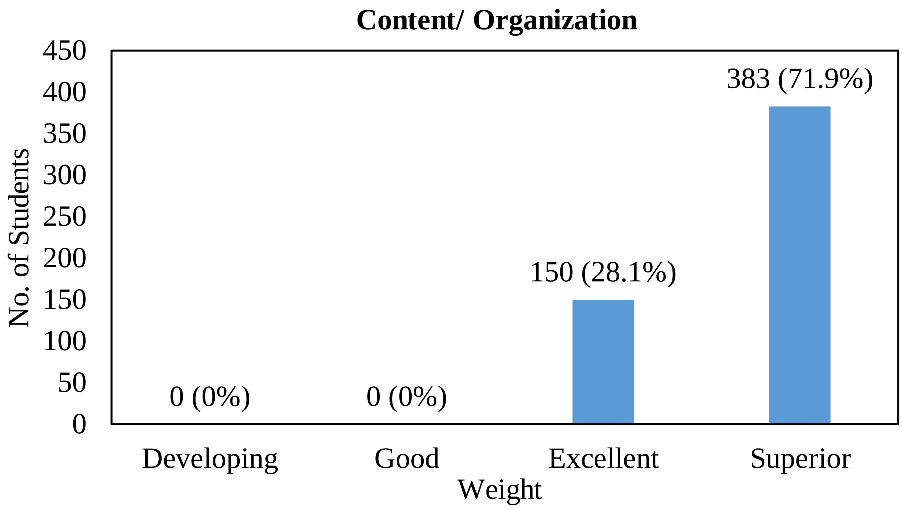


Fig. 7 The content/organization criteria assessments.

4. Conclusion and Future Work

Based on the direct assessment results conducted for undergraduate students, who took a course in Dynamics, from the Civil Engineering program, the students appeared to achieve all the performance criteria at an acceptable level. Despite this, improvements are still needed in several areas. This is facilitated through the upgrading of teaching and learning activities, including introducing actual engineering problems to enhance students' ability to identify, formulate, research in the literature, and analyze complex civil engineering problems reaching to the substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

This research will be continued with a post-assessment to determine the difficulties that students may experience while meeting the rubric requirements. Besides, the future work of this study will take advantage of other activities related to students' learning outcomes at the program level, activities related to interpersonal skills, ethics and professionalism, teamwork, leadership, and communication, and to ensure that students also have the skills to excel in professional environment.

5. Acknowledgments

The authors would like to thank the students for their valuable contributions to the Dynamics project.

6. References

Andrade, H. L., & Heritage, M. (2017). *Using formative assessment to enhance learning, achievement, and academic self-regulation*. Routledge.

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

Bishop, W., Nespoli, O., & Parker, W. (2012). Rubrics for accreditation and outcomes assessment in engineering capstone projects. *Proceedings of the Canadian Engineering Education Association (CEEA)*.

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

Dawson, P. (2017). Assessment rubrics: towards clearer and more replicable design, research, and practice. *Assessment & Evaluation in Higher Education*, 42(3), 347-360.

Jonsson, A., & Svingby, G. (2007). The use of scoring rubrics: Reliability, validity, and educational consequences. *Educational research review*, 2(2), 130-144.

Malini Reddy Y. & Heidi Andrade (2010) A review of rubric use in higher education. *Assessment & Evaluation in Higher Education*, 35(4), 435-448

Panadero E., & Jonsson A. (2013). The use of scoring rubrics for formative assessment purposes revisited: A review. *Educational Research Review*, 9, 129–144.

Popham W. J. (1997). What's wrong - and what's right - with rubrics. *Educational Leadership* (2), 72.

Prins, F. J., de Kleijn, R., & Tartwijk, J. V. (2017). Students' use of a rubric for research theses. *Assessment & Evaluation in Higher Education*, 42(1), 128-150.

Ragupathi K., Lee A. (2020). Beyond Fairness and Consistency in Grading: The Role of Rubrics in Higher Education. In: Sanger C., Gleason N. (eds) Diversity and Inclusion in Global Higher Education. Palgrave Macmillan, Singapore.

Sadler D. R. (2009). Indeterminacy in the use of preset criteria for assessment and grading. *Assessment & Evaluation in Higher Education*, 34(2), 159-179.

Sáiz Manzanares, M. C., Sánchez Báez, M. Á., Ortega-López, V., & Manso Villalaín, J. M. (2015). Self-regulation and rubrics assessment in structural engineering subjects. *Education Research International*, 2015.

Schoepp, K., Danaher, M., & Ater Kranov, A. (2018). An effective rubric norming process. *Practical Assessment, Research, and Evaluation*, 23(1), 11.

Susan M. B. (2013). *How to Create and Use Rubrics for Formative Assessment and Grading*. Paperback: Association for Supervision & Curriculum Development (ASCD).