Engineering Courses' Assessment: Rubrics Added Value Using Time Factor

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Abstract: Assessment is not an end in itself but a vehicle for educational improvement. Assessment is vital to the educational process as it enhances teaching and learning, promotes accountability, motivates students, guides instructional decisions, and drives systemic improvements. Assessment plays a crucial role in the educational process as it serves multiple important functions. Firstly, assessment provides feedback to both students and educators, allowing them to gauge the effectiveness of teaching and learning strategies. It helps identify areas of strength and areas that need improvement, enabling targeted interventions and adjustments in instruction. Furthermore, assessment fosters accountability by objectively measuring student performance against predetermined standards or learning outcomes. It ensures that educational goals are being met and provides evidence of achievement to various stakeholders, such as parents, educational institutions, and policymakers. Assessment also promotes student engagement and motivation. When students understand how their progress is being measured and evaluated, they are more likely to take ownership of their learning and strive for improvement. Meaningful assessments can inspire a growth mindset, encouraging students to embrace challenges, reflect on their strengths and weaknesses, and develop a lifelong love of learning. By embracing effective assessment practices, educators and institutions can create an environment that nurtures student growth, fosters academic success, and prepares learners for future challenges. Time factor in practical course work is essential to show how much professionality and confidence of student to do practical work. this paper has real example how can educators can judge learner's professionality depending on time factor added on Rubrics.

Keywords: Assessment, Rubric, Time factor, Engineering, Scoring.

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Introduction

Assessment plays a crucial role in the educational process as it serves multiple important functions. Firstly, assessment provides feedback to both students and educators, allowing them to gauge the effectiveness of teaching and learning strategies. It helps identify areas of strength and areas that need improvement, enabling targeted interventions and adjustments in instruction. Teaching Engineering courses has its own special terms and

distinguished provisions , unlike other subjects and courses e.g. humanities and linguistics that depend on pedagogical thinking based on memorizing and recalling facts and expression, which can be summarized into pure knowledge based in human mind. On the other hand engineering studying and understanding is based on rules to build knowledge to be used in practical thinking to produce object, this object can be tangible (e.g. control sensor) or can be intangible (e.g. code to control sensor) Pinter, R., Radosav, D., Cisar, S.M. (2012).

We can say in any engineering course there is a pedagogical (theory) part and practical division , to be fair enough 30 percent is theorical that needs build up knowledge and develop related hypothesis used for problem solving that based on rules and problem systematic understanding and analysing (Reynders, G., Lantz, J., Ruder, S.M. et al. (2020) , and about 70 percent is practical work to apply the conducted rules and related knowledge into real application , which can be considered as skills (T. Sasipraba, R. Kaja Bantha Navas, and others (2020)). One of main factors of teaching and learning process is assessment, even for case of when self learning , assessment is judging the level of learning and understanding. Basically if we are talking about engineering education assessment , so we need to methods to measure how much knowledge is comprehended and how much accurate skills are performed (Rajohane Matshedisho, 2020) .

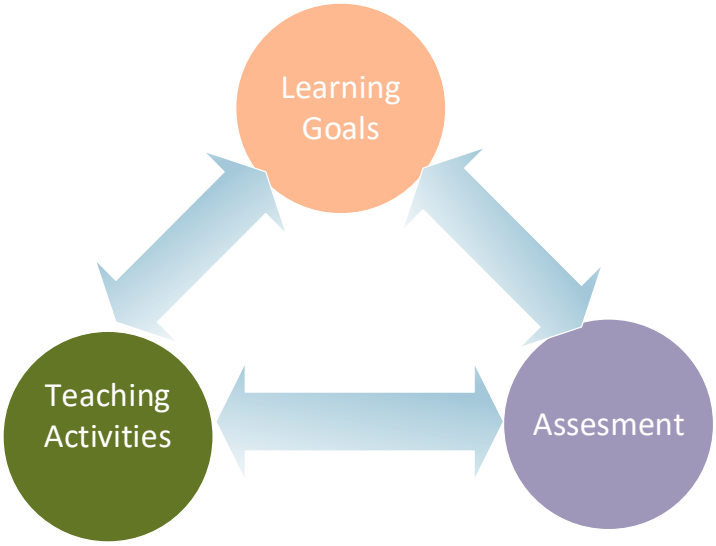


Figure 1. Assessment is Main Factor of Learning and Teaching

Assessment is considered one of the main factors in education, [1] the assessment method set by teacher must be: clear and understandable for students There are five considerations to examine when designing an appropriate assessment method that will reflect the established learning goals and activities (Aida MUSTAPHA, Noor Azah SAMSUDIN, Nureize ARBAIY, Rozlini MOHAMED, Isredza Rahmi HAMI 2016):

1. Reliability
2. Standardization
3. Validity
4. Practicality
5. Timeline

Reliability is the extent to which a questionnaire, test, observation or any measurement procedure the same results over a period of time. ***Standardization*** establishes a set precedence, therefore enhancing an assignment, test or projects' *reliability*. ***Validity*** is defined as, the extent to which the instrument measures what it sets out to measure. Teachers must identify the expected learning outcomes and goals of the course in order to appropriately assess student work. ***Practicality*** refers to the action of the assessment method and its relevance to the overall learning goals in the course. It also addresses whether or not the workload for the instructor is reasonable. ***Timeline i***s added consideration for *practical work* , this assessment is considered for time taken for practical job accomplishment (Florence Martin. (2022)).

Assessment of practical courses focuses on evaluating a student's hands-on skills, ability to apply theoretical knowledge in real-world scenarios, and problem-solving capabilities. The assessment methods for practical courses can vary depending on the nature of the subject and the specific learning objectives. Here are some common assessment approaches for practical courses that can be simplified in ***Rubric assessments*** :

1. **Lab Work**: Students perform experiments or practical tasks in a laboratory setting, and their performance is assessed based on the accuracy of their work, adherence to procedures, and the quality of results obtained.

2. **Projects**: Students undertake practical projects that require them to design, build, or implement solutions to real-world problems. The assessment includes evaluating the project's effectiveness, innovation, and overall execution.

3. **Fieldwork**: For certain disciplines like environmental or civil engineering, fieldwork may be involved. Students conduct site visits, collect data, and analyze it to solve practical challenges. Their abilities to analyze data and propose solutions are assessed.

4. **Practical Examinations**: These assessments are conducted in a controlled environment where students must perform specific tasks or solve problems in real-time, demonstrating their practical expertise.

5. **Portfolios**: Students compile a portfolio showcasing their practical work throughout the course. This can include project reports, lab notes, photographs, and reflections on their learning experiences.

6. ***Simulations***: In some cases, simulations or virtual environments are used to assess practical skills. Students interact with these simulations, and their performance is evaluated based on the outcomes.

7. ***Peer and Self-Assessment***: Students may assess their peers' work, providing valuable feedback, and also evaluate their own progress and learning.

8. ***Industry Collaboration***: Collaborating with industry partners on practical projects can provide authentic

assessments, as professionals from the field can evaluate the students' work.

9. ***Documentation and Reports***: Students are required to document their practical work and present detailed reports that showcase their approach, methodologies, and results.

The rubric assessment methods aim to assess not only the technical skills of students but also their ability to think critically (Pravin G Kulkarni, Ami R Barot (2019), troubleshoot problems, work collaboratively, and effectively communicate their findings. It's essential for practical courses to provide a well-rounded evaluation that prepares students for real-world engineering challenges.

Methodology

Certainly! Rubrics plays a significant role in engineering courses assessment, providing practical applications and hands-on experience. It allows students to understand the principles of practical courses such as automation, control systems, and mechanical design. Rubric method also integrates the assessment of various interdependent disciplines such as mechanical engineering, electrical engineering, and computer science. By studying robotics, engineering students can gain insights into cutting-edge technologies and develop skills in programming, mechatronics, and system integration. Overall, rubrics offers a valuable platform for exploring the intersection of engineering . it considered as a successful assessment techniques embody creativity, adaptability, reliability, and validity. Through the use of multiple methods, triangulation, and the measurement of knowledge and performance over time, effective assessment techniques can begin to capture and reflect the complex nature of learning.

Assessment method is considered one of the most important item in education, it is the pointer that point to the quality assurance , and auditing the whole education process , if there is no assessment method take in consideration the upper mentioned (in introduction section) items in assessment exams that means the entire education method has defect and must be revised , and it may reach teacher dishonesty and cheating. The good teacher will take in consideration the result of test to reassessment for students that comprehend knowledge and weakness for skill accomplishments.

A rubric is typically an evaluation tool or set of guidelines used to promote the consistent application of learning expectations, learning objectives, or learning standards in the classroom, or to measure their attainment against a consistent set of criteria. In instructional settings, rubrics clearly define academic expectations for students and help to ensure consistency in the evaluation of academic work from student to student, assignment to assignment, or course to course. Rubrics are also used as scoring instruments to determine grades or the degree to which learning standards have been demonstrated or attained by students (Alan Chony, Lisa Romkey (2012),

In courses, rubrics may be provided and explained to students before they begin an assignment to ensure that learning expectations have been clearly communicated to and understood by students, and, by extension, parents

or other adults involved in supporting a student's education. Rubrics may take many forms, but they typically include the following information:

Rubrics are generally designed to be simple, explicit, and easily understood. Rubrics may help students see connections between learning (what will be taught) and assessment (what will be evaluated) by making the feedback they receive from teachers clearer, more detailed, and more useful in terms of identifying and communicating what students have learned or what they may still need to learn. Educators may use rubrics midway through an assignment to help students assess what they still need to do or demonstrate before submitting a final product. Rubrics may also encourage students to reflect on their own learning progress and help teachers to tailor instruction, academic support, or future assignments to address distinct learning needs or learning gaps. In some cases, students are involved in the co-creation of rubrics for a class project or for the purposes of evaluating their own work or that of their peers (Juneidi, 2020)).

Since rubrics are used to establish a consistent set of learning expectations that all students need to demonstrate, they may also be used by school leaders and teachers as a way to maintain consistency and objectivity when teaching or assessing learning across grade levels, courses, or assignments. While some schools give individual teachers the discretion to create and use their own rubrics, other schools utilize "common rubrics" or "common assessments" to promote greater consistency in the application and evaluation of learning throughout a school. In most cases, common rubrics are collaboratively developed by a school faculty, academic department, or team. Some schools have common rubrics for academic subjects, while in other schools the rubrics are utilized across all the academic disciplines. Common rubrics and assessments can also help schools, departments, and teaching teams refine their lessons and instructional practices to target specific learning areas in which their students tend to struggle. Rubrics are often locally designed by a district or school, but they may be provided by outside organizations as part of a specific program or improvement model.

Assessment	Criteria	Sub-criteria	Level	1	2	3	4	5
Simple Project Using Programming Arduino that	Ability to apply and collect data type or data	Appropriate choice of variable names or data structure (i.e. array/ linked list)	P3	Unable to identify required data type or data structure	Able to identify required data type or data structure but does apply correctly	Able to apply required data type or data structure but does not produce correct results	Able to apply required data type or data structure and produce partially correct results	Able to apply required data type or data structure and produce correct results
	Ability to apply required control structure and program	Correct choice of sequential, selection or repetition control structure	P4	Unable to identify required control structure	Able to identify required control but does apply correctly	Able to apply required control structure but does not produce correct results	Able to apply required control structure and produce partially correct results	Able to apply required control structure and produce correct results

	Ability to run/debug Data are collected and transmitted to Cloud	Free from syntax, logic, and runtime errors	P3	Unable to run IoT System	Able to run IoT System but have logic error	Able to run IoT System correctly without any logic error	Able to run IoT System correctly without any logic error and display inappropriate ate readings	Able to run IoT System correctly without any logic error and display appropriate e readings
	Ability to perform input validation Transition	Validate input for errors and out-of- range data	P3	The IoT System produce s incorrect results	The IoT System produces correct results but does not display correctly Does not check for errors and out-of- range data	The IoT System produces correct results but does not display correctly. Does little check for errors and out-of- range data	The IoT System works and meets all specifications. Does some checking for errors and out- of- range data	The IoT System works and meets all specifications. Does exception al checking for errors and out-of- range data

Table 1. Rubric Scoring Criteria for Engineering Internet of Things (IoT) Project

Actual Class Scoring

In undergraduate session we had applied the upper mentioned rubric on an IoT assignment, the scores of the student for a given project are shown in Table 2 with no time factor is added. The project is reading and collecting data from installed sensors for temperature and humidity then transmit the data every 10 minutes to cloud to be stored in file in bigdata system, the distribution of the scores are given in Figure 2 the final score with no time factor of accomplishment's is given in Figure 2 .

Criteria	St1	St2	St3	St4	St5	St6	St7	St8	St9	St10	St11	St12	St13	St14	St15
Ability to apply and collect data type or data	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ability to apply required control structure and program	5	5	5	5	5	5	5	5	3	5	3	5	5	5	5
Ability to run/debug Data are collected and transmitted to Cloud	5	4	5	5	5	1	4	2	2	5	3	4	5	5	5
Ability to perform input validation transmition	4	4	5	5	4	1	4	1	1	5	1	3	5	2	5
Total	19	18	20	20	19	12	18	13	11	20	12	17	20	17	20

Table 2: Fifteen Students' Scores with No Time Factor using Rubric described in Table 1

Table 3 shows the scores of the same fifteen students with time factor added , Considering that for each criteria 5 points and we have 4 criteria that means the full mark will 20. We must notice that practical work can be partitioned and categorized into steps, each step is depending on the previous one so if student is failed to do the first step he/ she will never be able to continue to the next step, that means zero score, but students some time start to search for solution using web or ask teacher assistant to figure out to do one step , that means he/she might

will find solution but with delay of time , so lets say the time needed to do this project needs 40 minutes (10 minutes) for each step then the student who solve all steps on time will gain 40 score over the project steps scores (5 max for each step) , if he/she late for each step more than 10 minuts or late to deliver the project more than 40 minuts this time will be subtracted from the time score.

Criteria	St1	St2	St3	St4	St5	St6	St7	St8	St9	St10	St11	St12	St13	St14	St15
Ability to apply and collect data type or data	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ability to apply required control structure and program	5	5	5	5	5	5	5	5	3	5	3	5	5	5	5
Ability to run/debug Data are collected and transmitted to Cloud	5	4	5	5	5	1	4	2	2	5	3	4	5	5	5
Ability to perform input validation transmition	4	4	5	5	4	1	4	1	1	5	1	3	5	2	5
Time accomblish	40	38	36	33	30	30	30	28	23	20	20	17	17	15	15
Total	20	19	19	18	16	14	16	14	11	13.3	10.7	11.3	12	10.7	11.67

Table 2. Fifteen Students' Scores with No Time Factor using Rubric described in Table 1

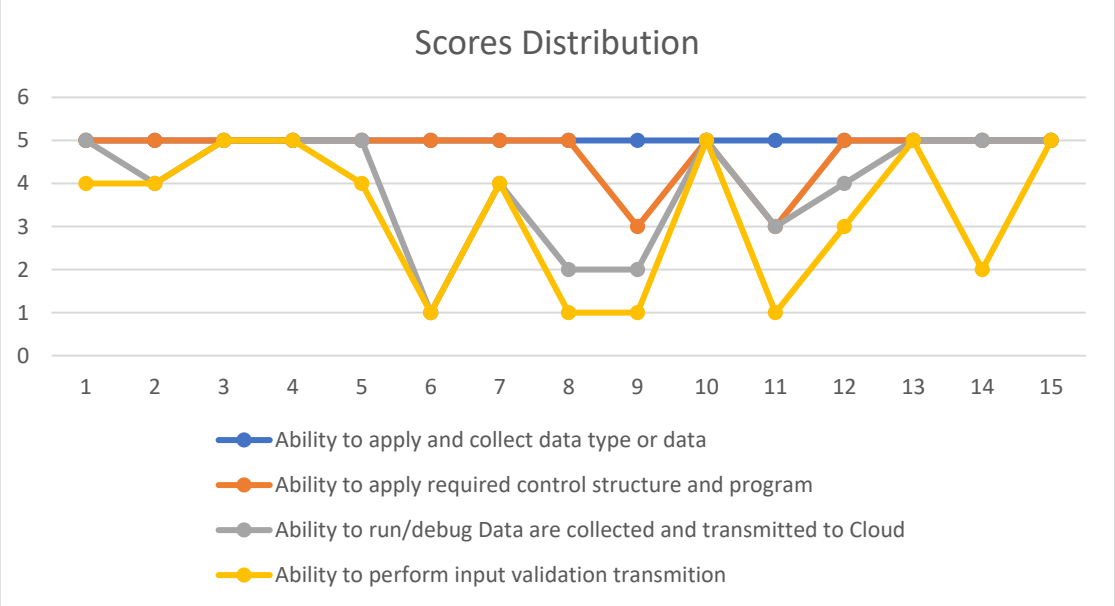


Figure 2. Actual Scores of Students for Each Step in Rubric

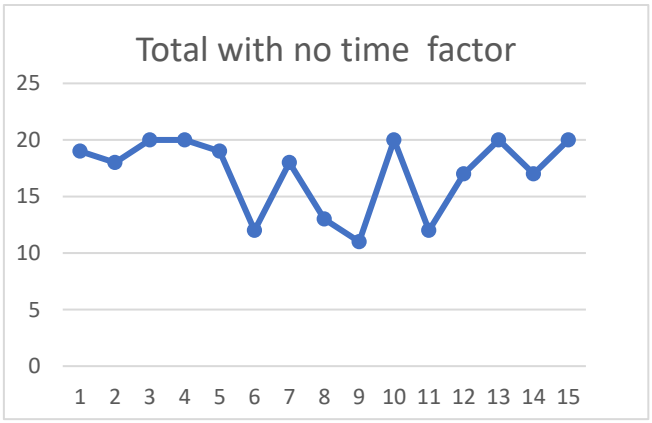
As engineering subjects and practices is a profession. We need to judge and estimate the professionality and confidence of student when accomplish a job. Rubrics with no time factor will fail to estimate professionality as all students finally will do the job as required but these students are not equal because some finished correctly on time or less, and other do the job after searching and hesitation that means he/she not well trained. The following equation with give more accurate values in students assessments which depicted in Figure 3 - A rubric no time factor assessment , and Figure 3 - B with rubric time factor added assessment

Time accomplish = Criteria $_{Time}$ - Latency $_{Time}$

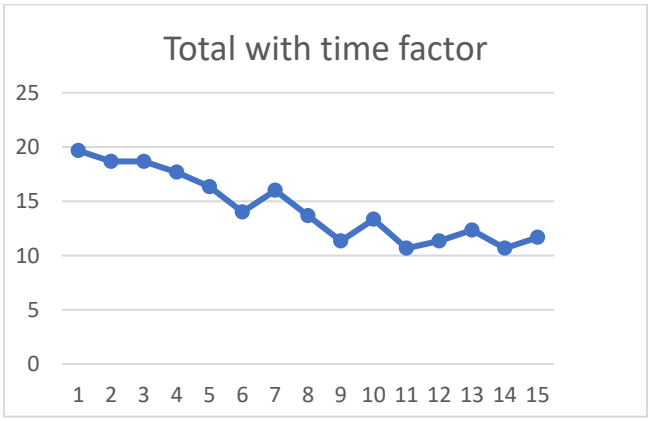
Time factor = Criteria $_{time}$ + 2*μ criteria $_{time}$

Total score = $\sum_{k=1}^{n}(scores + time\ accomplished)$ * Full score / Time factor.

Where **μ** is the average of time criteria.



(A)



(B)

Figure 3. Total Score for Project without Time Factor (A) and with Time Factor (B)

We can see from Figure 3 that the students scores are arbitrary distributed with no normalized distribution, and no justice in this assessment , this result is caused because we did not consider the time of accomplishment. Turnes out that all student may be above 90% and some below 70% , which indicates that some thing is wrong and there is a huge gap. But if we took into consideration Figure 3 (B) we see the student who has some late time will lose scores as they showing in-confidence in solving project steps and they may get some help from internet assistant or asking for other help .The result in this part scores shows a normal distribution , notice for example student number 10 he/she has full mark in first method but he/she has 13.3 only instead of 20 , and notice the student number 15 who has the largest late time even though he /she has all steps done as 5 score but total score declined from 20 into about 12, this method is more accurate and honest to be used for engineering courses, because their must be differentiation between student that do activity without assistant and hesitation and other student who may be waiting assistant to make sure the all steps are done. Well, this differentiation means unprofessional and professionality.

Conclusion

This paper is pointing out two things , First the assessment is an essential component in education, , so assessment is not the end but the start to enhance course work, it is appropriate tool to overcome teaching/ learning pitfalls by defining weaknesses to be overcome . Engineering courses normally have more than 70% of practical work and project. This paper shows the important of time factor to do a practical work and projects , from long experience projects can be done correctly by students sooner or later , but we need to distinguish between the one who is doing project with confidence and professionality, and the other who need more training or assistant to get job done , This paper presents formulas depended on time factor that can be added to any kind od rubric items. From a case study, we find that when we added time factor for practical work we have seen more normal distribution and more rational scores which are more reasonable and more convincing to student to know his/ her weaknesses.

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