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A new method of individual student assessment in team projects

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ABSTRACT: Assessment processes used for student works have significant differences. A good assessment framework for individual student grades in team projects should be developed. This study evaluates the effectiveness of a team charter (TC) approach in a fluid machinery unit for assessment of individual student grades over other student assessment approaches. The impact of this approach is evaluated using Central Queensland University's (CQU's) on-line Student Experience Survey (SES) data. With careful evaluation of these data, the effectiveness of the TC approach is assessed. For further refinement, several recommendations are proposed through an annual unit enhancement report to the programme committee of the School of Engineering and Technology, CQU, for implementing improvements in the next offerings. The satisfaction data of the fluid machinery unit obtained by SES until 2016 were low and produced many student queries relating to assessment of student portfolios. Using the TC approach, the SES data showed that student satisfaction improved significantly over the corporate target in 2017 and this has been sustained since then.

Keywords: Project-based learning, team charter, student motivation in learning, assessment framework

INTRODUCTION

There are two major approaches in university teaching: teacher-centred/content-oriented (traditional)/instructive delivery (lectures)/formative (quantitative) and student-centred/learning-oriented (project-based learning - PBL)/constructive approach (workshops)/summative (qualitative) [1]. The traditional engineering units and PBL units are different in delivery and assessments. The formative or quantitative approaches are generally used to assess student works focussing on technical engineering content knowledge. Students are employing relevant engineering equations to determine solutions of the problems. It is a clear and routine way to assess a student's content knowledge. Summative or qualitative approaches, on the other hand, are more suitable for assessing each student's works in PBL methods focussing on content-based problem-solving skills along with engineering practice skills, such as professional, research and context dependent skills.

Howard and Eliot pointed out that Engineers Australia (EA) accreditation teams showed *mistrust* of qualitative assessment as it was subjective, and not a general method [2]. Therefore, assessment in PBL units should be undertaken in a way that focusses on student's learning in both content and context-based capabilities suitable for engineering practices. It is noted that the PBL approach of delivery is becoming more popular in Australian universities [3-5]. In PBL units, each student's collaboration is most important in completing their team projects. Giving equal marks to all students discourages student collaboration. In the PBL approach, different methods of assessing/calculating individual marks/grades are presented. The methods discussed are portfolio-based criteria, self and peer assessment (SPA) and team charter (TC) methods. All these methods use their own particular way of assessing an individual student's achievement of learning outcomes (LOs) set for the PBL units.

Portfolio Method

For individual student's assessment of grade in a team situation, the portfolio system, a holistic approach was initially introduced. This approach has been adopted internationally as a valid method for assessing individual student learning in various engineering institutions [6-8]. There are many components integrated in a student portfolio. They are grade nomination (self-nomination of grade satisfying learning outcomes of the unit mapping with the marking rubric), completed team-based project reports, fortnightly reflective journals (done by individual students), reflective papers (done by individual students), team laboratory reports, demonstrated problem solutions (done by individual students), class tests, drawing folders, *viva voce* and self and peer assessment results. The requirements of these components in a portfolio are different in lower and higher levels of engineering studies. Taylor et al formulated a structured portfolio assessment strategy

through a reflective practice considering a few changes in portfolio assessment steps: changing the 100% portfolio submission in the examination week to progressive submissions of different items in different weeks with the final 30% individual portfolio submission in the examination week [9]. The authors claimed that students' overall satisfaction improved significantly along with student satisfaction in assessment tasks, learning resources and Moodle navigation.

After careful consideration/reading of the claims, examples and evidence, the markers allocate a grade bearing in mind both the grade assessment tool and grade rubric. The grade given by the assessor can be the same or different to that nominated by the student; the student's nominated grade can be agreed with, upgraded or downgraded. The final student grade is allocated by a moderation meeting among the unit's teaching team members. The main focus is given to those grades that are on the borderline between two grades. In the School of Engineering and Technology, CQU, this portfolio approach was used recently in PBL high level units in 4th year [4] and 3rd year [10]. For better preparation of students' portfolios, some changes in the portfolio process can be made, such as shifting 100% portfolio submission at the end of the term to the progressive submission of some portfolio parts, while keeping the last 30% portfolio submission until the end. More feedback during the terms enhances students' learning skills. Some formative marking processes recently introduced in student projects facilitate clearer students' perceptions of their offered marks [10].

SPA

The self and peer assessment (SPA) is another approach which is used widely in educational institutions. This approach determines the final grades for individual students based on the average peer assessment score each student received from their team members [11]. Falchikov and Goldfinch indicated this method reflected an issue of *social desirability bias* [12]. At the end of the project, students submit an SPA sheet giving points for himself/herself and other team members in the team following 5-point or similar scales on different categories/scopes [13] or indicating the relative individual contributions of the team efforts in team projects in percentages [14]. When the team project is graded based on an assessment sheet by the lecturer, the information (point/mark) on each SPA sheet is used to calculate individual marks/grades for team members by using the project marks given by the lecturer and relative ratings calculated from SPA information. The main part of this calculation is the relative rating obtained from SPA data given confidentially by students to the lecturer.

TC Approach

The team charter (TC) approach, also called holistic peer assessment, as used in this article calculates individual marks/grades in teams based on students' contribution/share of different elements/scopes in the project in percentages [3] given by the team members in a single document to the lecturer with their signatures. This individual contribution in percentages is based on an agreed understanding of it reached in a team meeting, avoiding any confusion of individual contributions given confidentially [13][14]. The research question of the study discussed in this current article is to identify the effectiveness of the TC approach in assessing individual student's marks on team-based projects. The research design used here is based on the shifting of a student's individual grade in team projects from a portfolio method to a team charter approach. The effectiveness of this shifting of research design is judged by the SES data and feedback given by the programme committee of the School through its annual unit enhancement reports. The implications and effectiveness of the TC approach are also judged by the qualitative and quantitative feedback given by the students, teaching team staff and CQU's on-line SES, respectively. This study involves 3rd year mechanical engineering courses with the student cohort consisting of school leavers, mature age students and students from diverse cultural backgrounds in both distance and multi-campus modes. An earlier version of this article was presented at the 2018 Australasian Association for Engineering Education Annual Conference [3].

METHODOLOGY

The TC approach focuses on individual contributions in percentages to calculate individual marks in team-based projects. The TC template is initially provided to the students to make clear the meaning of contributions in percentages in different scopes of the project. It is expected that a total of 100% contributions are distributed among the team members. Two methods can be used: mutual understanding of their contributions in percentages or each student submits their individual percentage contribution of scopes of the project confidentially to the lecturers to calculate an individual weighting factor (IWF). The first method is used in this article to calculate individual student marks in team projects. For the latter method, the facilitators collect all the individual points/contributions in percentages and can average all of them for each team to produce a final team contribution table to calculate individual marks. In the TC method considered, the facilitators produce a table and students in a team input each student's contributions data in percentages into that table and all the students sign it. A typical table (Table 1) can be used for this purpose. As this is an agreed and signed document, it can be easily used to calculate the individual marks in team projects.

Unlike the SPA, the TC has some clarity in percentage distribution. It is shown that a total 100% is distributed across four sub-sections (a, b, c and d) and each sub-section has some specific project scopes to be completed (Column 2 of Table 1). Based on each student's contributions and activities, they are putting numerical figures in each row a, b, c and d (Table 1) that add up to the total percentage allocated to that sub-section. As a result, total individual percentage contribution data presents a representative value for the complete project. Grade assessment using this method has two steps: grading of a team submission and an individual grading of each of the team members. When grading of a team

submission is completed using the team assessment criteria sheet, then the individual grade will be determined based on each student's performance and contribution to the team submission (Table 1).

Table 1: TC method for identifying each student's contribution in percentages.

Items	Load of scopes in percentages	Agreed contribution of team members in percentages							
		Name M1	Name M2	Name M3	Name M4				Comments
a	For scope nos. 1, 2, 3, and 4: 25%	…	…	…	…				∑25%
b	For scope nos. 5, 6, 7, and 8: 30%	…	…	…	…				∑30%
c	For scope nos. 9, 10, and 11: 30%	…	…	…	…				∑30%
d	For scope no. 12: 15%	…	…	…	…				∑15%
Total	100%	25%	30%	20%	25%				∑100%
Signature									

Each student's contribution will be determined by the completed team charter (Table 1) signed by the team members and submitted to the unit Moodle site. The individual student marks for the team submission can then be determined using some equations. An example is given below. It is possible that an individual mark may be higher, lower or equal to the team submission mark. However, a maximum individual mark can be capped at the maximum mark allocated to the assessment. An example consideration is carried out in a team of four team members: M1, M2, M3 and M4. Assume that this team receives a team submission mark of 20 out of 25 (25 is the total mark allocated for a project), and that the final signed team charter presents the following individual contributions in percentages: M1 25%, M2 30%, M3 20% and M4 25% as per the submitted team charter (total is 100% and a fair (equal) share is 25% for a team of 4).

The individual weighting factor (IWF) defined by Cheng and Warren [15] inspired the author of the current study to redefine a new IWF factor. The IWF overcomes the possibility of unfairness of giving the same marks to all team members carrying out a project. The new IWF factor is as:

$$IWF = \textit{individual contributions to projects/fair share of contributions} \quad (1)$$

The individual student's score against the 20 marks awarded for the project are now calculated as: M1 = 20 x (25/25) = 20 out of 25; M2 = 20 x (30/25) = 24 out of 25; M3 = 20 x (20/25) = 16 out of 25; M4 = 20 x (25/25) = 20 out of 25. This clearly shows that team project marks and individual student's marks are different. It encourages team collaborative works and achieves good project outcomes. However, these SPA or TC methods do not relate students learning in grade calculations; it is based on percentage student contributions. The author provides some insights regarding how this marking strategy can map progressive student's learning for different engineering skills. The individual rating can be obtained differently by considering marks/efforts from seminars, *viva voce*, seminar presentations and individual awards. The average of fair share or rating for each team is obtained by summing all individual ratings/contributions for the team and dividing by the total numbers of team members.

RESULTS AND DISCUSSIONS

Many professional bodies, such as Engineers Australia require that both fundamental engineering core knowledge and professional skills are necessary for accreditation of engineering programmes. The following professional skills are essential for industrial project works: interpersonal relationships and individual responsibilities, personal transferable skills of communication, presentation and problem-solving skills, leadership and time management skills, delegation and organisation skills, learning through discussion and debate, and justification of ideas [10].

The assessment task requirements and grading of team projects are set forth in a way to satisfy EA accreditation requirements. The TC model for assessment of student team projects is therefore not based on any conditions set only for CQU's students. The scopes of the project and the distributions of marks relating to the scopes are defined by the lecturers; the operation of these steps (Table 1, Equation 1) is carried out in an Excel sheet. The processing of student feedback data obtained through SES at CQU can be managed by other learning management systems (LMS) [16], such as WebCT, Blackboard, Moodle, etc, used in other national and international institutions. If this software is not available in an institution, a paper-based feedback method can be adopted [3]. Therefore, the TC approach and its implications are equally valid and effective for educational institutions in Australia and other countries. The following sections illustrate the key points of the TC approach including the use of relevant quantitative and qualitative data.

General

It had been noted that there was low ability of engineering graduates to apply knowledge to industry problems [17]. To develop student's skills in both areas (content and professional) and to ensure that engineering graduates are ready

to join their professional workplace, some active learning approaches are required through PBL methods [10]. Initial approaches allocated equal marks/grades to all team members, and this was not a correct method [15][18]. A particular form of peer assessment needs to be employed to meaningfully factor individual contributions in collaborative team works. If a particular SPA or TC is employed, many of the students receive a different grade to that received if the same grade is awarded to all team members [15]. Cheng and Warren also demonstrated clear benefits and drawbacks of group works [15]. It is a responsibility of the coordinators/lecturers to award appropriate grades/marks to ensure fairness to those students whose contributions are higher than those of the other members of their team. As a result, student interest, engagement and satisfaction improve.

Table 2 shows student satisfaction scores obtained by the CQU's Moodle system for the last four years. The student satisfaction score is produced following a 5-point Likert scale where 4.0 is a corporate target. It is clear from Table 2 that SES data for student satisfaction is very good from 2017 onwards, being in the green zone of the university colour code system. The student satisfaction score increased to 4.1 in 2017, 4.6 in 2019 and 4.5 in 2020. These data are statistically viable when the student number in a unit is 10 or more and the student feedback rate is 50% or more [3].

Table 2: Satisfaction and response rates.

Year/unit		2016	2017	2018	2019	2020
A PBL unit	Student numbers	37	33	112	78	19
	Student satisfaction	2.4	4.1	4.4	4.6	4.5
	Student feedback rate (%)	58	74	55	70	79

The author introduced the TC approach in 2017 for the first time. The assessment processes were adopted categorically, and it was expected that the student enquiries would be less. The author of this article got less enquiries at the end of the terms from 2017 and the students are generally happy due to the clarity in individual assessments in team projects (Table 2). It is clear from this table that student feedback rates are very good, being well over the 50% corporate target. The student satisfaction data until 2016 was not good and it was 2.4 in 2016. There were a few interventions employed during 2017 and the TC was one of them. The data set shows that student satisfaction was significantly improved over the corporate target (4.0 in a 5.0 Likert scale) with no student learning problems. It suggests that the clarity of the TC in individual assessments in team submissions enhances student satisfaction, team project collaboration and student learning.

Some qualitative data from students and staff in the teaching team are important to note. It can reinforce the author's argument about the suitability of assessing individual student performance in team projects. One student pointed out *…This unit was very interesting to learn as it contains core knowledge about the engineering. The hydraulics projects and its assessment done in this subject helped me to gain more knowledge about the hydraulics and the steps of assessment and encouraged me to search more details about this subject. The outcomes from this unit can be applicable in our future projects either in workplace or in this innovative world* (student feedback, 2018).

Feedback from a staff member in the author's teaching team from CQU Melbourne Campus in 2018 iterated some points relating to this TC approach, *…it would be one of the efficient techniques to manage students complaining that a non-cooperative student does not deserve the same marks as a significant contributing student in the same team. It would be easy to manage a few students from different backgrounds and culture to work together as a team. The student can easily understand the significance of their contribution to the team project to achieve the minimum grade to meet the requirement. It helps the assessor for fair assessment and providing individual marks based on the contribution (% of share) they declared that was agreed by the other teammates as a piece of evidence for mark distribution. It can help to identify contributing students in a team*.

Although the focus of this article is individual assessment in team projects, additional innovative L&T practices, such as good scoping of industry projects, clear assessment requirements, regular and timely feedback, etc, are important. The SES provides student ratings on the 5-point Likert scale with 4.0 as the corporate target on various aspects of the projects, such as assessment tasks, assessment requirements, assessment returns, etc. The definitions of these descriptors are illustrated in Table 3.

The SES is an anonymous survey to tell the unit coordinator what students think of the unit. The unit coordinator uses the information students provide to enhance the overall unit design and delivery, assessment and outcomes for the unit enhancement processes. It is expected that the unit provides the students with an effective learning experience and helps the students to reach their full potential and skills, meeting the work ready requirements for graduates. The anonymous aggregated student feedback is used in the Moodle site through unit profiles to show changes that have or have not occurred, and it is also posted in the CQUni handbook and released to the Unit Coordinators, Deputy Deans and Dean of School, and the Learning and Teaching Services. The descriptors for students to provide feedback through SES are presented in Table 3. The TC method is directly related to some of the tasks, such as assessment task, assessment feedback, etc.

The data set clearly illustrates that, with proper assessment of industry team project outcomes, the student satisfaction score can be improved significantly over the corporate target. The corporate target is considered for benchmarking of the unit's performance. If the students' rating is over the target, the unit is considered to be in the green category and no

further critical interventions are needed [3]. A recent study by Shashavan and Jalili articulated that a proper peer assessment of student team projects, such as the TC method, can improve student appreciation by 10% and decrease the complaints by 19% as compared to the *free riding* methods [11].

Table 3: Various descriptors on student feedback of SES.

Items	Definitions	Comments
Assessment task	The assessment tasks in the unit helped students to learn.	The assessment tasks are relating to engineering problems in context with good objectives and scopes.
Assessment return	The assessment work was returned in a timeframe that supported student learning.	With both useful qualitative and quantitative feedback provided back to students within two weeks after the date of submission.
Moodle navigation	How easy is it to navigate the unit Moodle site?	The site must be user friendly with similar resources available in a single place.
Assessment feedback	The feedback given on the assessment work helped students to learn.	Both qualitative and quantitative feedback to each student would be such that they help improving good points and rectifying the issues.
Assessment requirement	The requirements for each assessment task were clearly explained.	The assessment requirements detailing to scopes, analysis, verification, submission details, etc, are explained clearly.
Learning resources	The resources provided in this unit supported student learning.	Along with engineering practice project scopes, enough resources, such as related lectures, tutorial and computer laboratory sessions and additional supporting materials and related recordings would be uploaded.
Overall satisfaction	Overall, students were satisfied with the quality of this unit.	It is relating to the feedback of the unit, not the teaching.

On the other side of these approaches, a question may arise about percentage contributions in Table 1; are they representative? If there is a teaming problem, contribution data can be manipulated even though they are individually signed off. Some team members can be in disadvantaged positions. A team combination can play an important role here. If the TC approach can be done in a way that each team member can populate all team members' contributions and upload this to the Moodle site independently, so that the unit coordinator can average all data from all team members, this modification can result in more representative contribution data.

The novelty of this article relies on the fact that the moderation happens separately on different parts of the assessment rather than doing it for whole portfolios. The steps of TC are clearly presented, and this removes the confusion of different students' grades in a team [11]. The peer assessment process also improves the co-operation of the members, the student teamwork experience and dynamics, and student engagement with the unit [1][11]. As the objective is to present the effectiveness of the TC method, final results/grades of the students of the unit discussed earlier are not presented. It is true that the TC approach alone cannot improve students' learning and satisfaction, it is based on class and tutorial activities, laboratory and project activities, etc. However, the use of TC helps to improve students' satisfaction, content knowledge, performance, engagement motivation, collaboration, and an overall positive learning experience.

From 2017, the number of student queries about their final grades after the certification day have been greatly reduced. Previously, the author of this article received many e-mails and telephone calls from students in relation to their dissatisfaction regarding different marks compared to other team members in the portfolio approach. They often failed to realise that their final grades were based on evidence they put into their portfolios, not based on the amount of teamwork. The student feedback on various descriptors (Table 3) is presented in Figure 1. It is clearly shown that the students' evaluation and satisfaction on various descriptors is very good for all the years since 2017, being over the corporate target including assessment task, assessment return, assessment requirement, etc. The overall student satisfaction of the unit is gradually increasing benchmarked against the corporate target.

It is noted that student individual assessments on team projects along with other assessment pieces is carried out in different weeks of the term. If the student learning falls below a passing level, outcomes of the TC approach can identity that. The respective students can perform corrective measures to enhance their performance with the help of the unit coordinator. This approach is better in monitoring the students' progressive learning journey.

Individual Student Learning

Howard and Eliot argued that individual student's learning should be linked to their grades or marks [2]. The students are demonstrating, with examples, their achievement on various areas of learning outcomes of the unit while compiling the grade nomination section in the portfolio approach. If the lecturer's understanding about the students' evidence on learning may be different to that of the students, confusion evolves. Each student's learning in SPA and TC approaches, on the other hand, is based on agreed or individual weighted percentage contributions, not on individual learning. The individual contribution has, nevertheless, some connection with student learning and it is difficult to quantify.

To ensure a general individual student learning on the total project areas, the author initiated a new approach, called a progressive individual student's learning that can be benchmarked with the student's grade obtained by the TC method to see if the student's grades are similar.

In the progressive individual student's learning, the author considered several things during weekly workshop sessions. They are monitoring the project scope plan, four-square chart, a standing weekly meeting agenda item and meeting minutes. An Excel sheet with the student names of each team with activities over 12 weeks is considered. Through the regular weekly meetings, the author documents his perception of each student's individual learning from a Q&A session [19]. As per the standing agenda item, each student presents his/her part including the solution techniques, assumptions used, etc, to other team members and *vice versa*. The author asks related questions to other students who did not present to see how well the knowledge had been transmitted to them and at what level. This process forms the students' learning on a concept. The outcomes are noted in the Excel sheet. At the end of week 12, each row of the Excel sheet provides a level of a particular student's individual learning on the project with a grade.

The author mapped the student Excel data to that of the student grades obtained by the TC method. Both types of grades are similar, thus suggesting a link between these two methods. For any major dissimilarity, the students are required to attend a *viva voce* to finalise their grades. All these processes are illustrated in the unit profiles, and they are communicated though the on-line student forum on the unit Moodle site. With the feedback from students and the full teaching team for the unit, a general progressive individual student's learning outcome will be framed. A detailed account of this method of assessing each student's individual learning with students' feedback on their perceptions of the process will be published in a separate article.

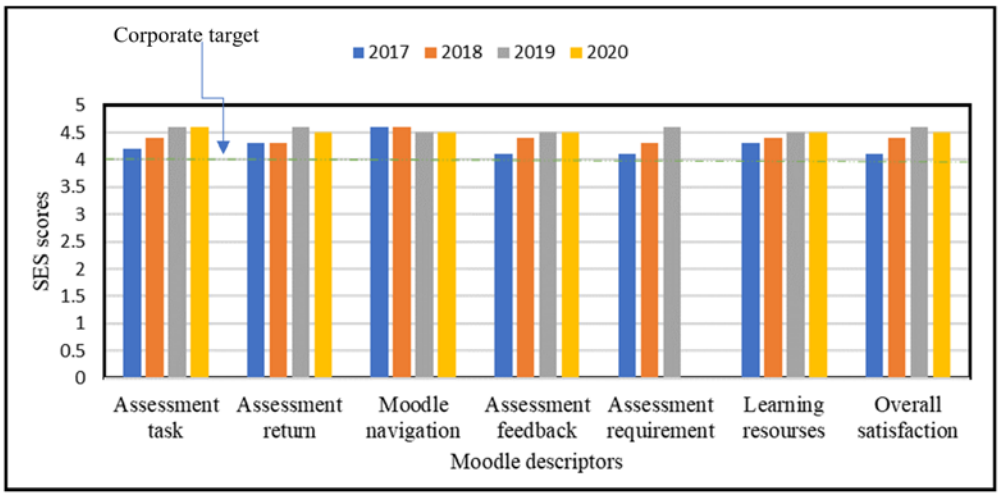

Figure 1: SES data for various Moodle descriptors.

Based on the above discussion, it is evident that this article not only describes a unit's teaching innovations, evaluated through a unit evaluation procedure with students self-reported learning and satisfaction, but it also presents a novel assessment process that can be of interest to readers outside the university where the work was carried out.

CONCLUSIONS

The TC approach has been utilised for assessment of individual performance in team-based projects in the author's PBL unit from 2017. Up to 2016, this was done by a portfolio method. The limitations of this study include only focusing on the students' satisfaction data obtained from CQU's SES system. Individual student assessment is based only on percentage contribution towards the project, not based on his/her individual learning. The non-solicited student feedback data should be considered. Future study can focus on this, along with the benchmarking of student satisfaction and feedback data against that from other studies published in the literature. Also, full integration of student progressive learning and student grade assessment by the TC method will be carried out in a separate article.

It is assumed that student contribution data is a genuine reflection of their contributions to teamwork. Calculated grades are based on the percentage of teamwork contributions, not their individual learning. From the results and discussions, the following conclusions are made:

1. the individual marking assessment process in TC method is clearer;
2. student queries at the end of the term are reduced significantly;
3. individual student progressive learning grades are mapped with the student grades by the TC approach and found to be consistent;
4. the TC approach positively influences student satisfaction;
5. use of the TC yields increased interest and stimulates curiosity of students to learn;
6. the TC approach is better in monitoring a student's progressive learning journey.

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BIOGRAPHY

Nirmal Kumar Mandal graduated from Bangladesh University of Engineering and Technology, Bangladesh. He obtained his Master of Mechanical Engineering degree from the same university. Later he achieved his PhD degree from CQU, Australia. Currently, he is working in the School of Engineering and Technology, CQU, as a senior lecturer in mechanical engineering. He has published thirty journal articles and thirty-seven peer reviewed conference papers, and he is working on work integrated learning, students satisfaction and learning, feedback and 3D printed models. He received six external research funding from industries in teams, with most recent one being: *Flow characteristics of venturi devices - dust suppression - mining* (50% fund from an industry and 50% from Commonwealth Business Fund) as a team leader. He has served his profession in several roles in Engineers Australia Local Committee since 2005 as a member, Deputy Chair in 2018 and Chair in 2019 and 2020. He is an Associate Editor of the Australian Mechanical Engineering Journal.