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A Structured Assessment Framework for Teamwork

Abstract

Anecdotal evidence from students shows that ACU undergraduates have difficulty managing their time due to various commitments and responsibility outside university. As such, this paper proposes a cooperative learning model which endeavors to help students utilize their time optimally in a first year programming course in MATLAB. Included in this model is a structured assessment framework, as well as teamwork training to facilitate effective teamwork strategy. This model also places emphasis on strong alignment of curriculum objectives to progressive assessment tasks.

To deploy this framework, a MATLAB programming project is designed to be just large enough for a group of 3 students to finish in one semester. To solve the problem of slow start with poor planning, the project is divided into six tasks; the first two are to initiate students individually into the project, as teams are to be formed only during the fourth week of semester. The remaining tasks are for when teams are formed. It is expected that by the time the teams are formed, each student is already familiar with the project and this is shown via continuous online discussions as well as written reports. Students who contribute more towards the project, evidenced by online discussions as well as CATME student peer evaluation results, are given bonus marks. It is anticipated that this framework can change the high achievers’ perception of teamwork; in normal teamwork environment, these high achievers feel that the poorer students waste their time. Also, the less talented students can be encouraged to participate strongly in the project, thus eliminating a significant number of “passengers”.

1. Introduction

“We need to work to support ourselves and we want a life, therefore time for study is scarce” depicts the typical full-time student characteristics in ACU, Australia. Part-time students, with ages varying between 25 and 50, have one or more of the following responsibilities:

- a demanding job;
- family; and
- the need to improve their career potential.

The scarcity of time for study is witnessed by the aforementioned student characterization and as such, it is desirable to design courses which consider the factors that have negative impact on students’ lives, given their various responsibilities outside university. There are three ways this can be achieved:

1. ensure coverage of course materials is not too heavy;
2. ensure alignment between teaching / learning activities, course curriculum, and assessment; and
3. make teamwork a prominent feature of the course.

Accordingly, this study proposes a framework to incorporate these options. In order to make teamwork a successful endeavor for students, teamwork training is included in the course
coverage, thus creating a system which interleaves teamwork training and MATLAB topics. Both topics are carefully aligned to weekly assessment tasks such that students can work on the project as soon as possible.

To enhance the teamwork training component of the course, CATME (Comprehensive Assessment of Team Member Effectiveness) [1] is used for peer evaluation and self-evaluation of team members. Furthermore, team members are assigned by a software tool called Team-Maker which makes up the teams. Team-Maker uses instructor-defined criteria (obtained from teamwork literature) to assign students to different teams [1]. Section 3 will give more details on CATME and Team–Maker.

2. Related Work

Much has been discussed on teamwork and team building or teeming as evidenced by the enormous amount of literature, both online and hardcopy as well as the vast number of books available for purchase. However, most of the theories, both in papers / articles and books, are about teeming in workplace with hardly any emphasis on teamwork in a university study environment. Team building theories tailored for organizations are not exactly applicable to teamwork in an educational setting. The fundamental difference here is people are paid to work in teams in an organization whereas in higher education, students are asked to be part of teams for a couple of reasons:

- reduced workload for the lecturers; if a class of 30 are to be formed into teams of 3 then the lecturer-in-charge will have only 10 copies of assignment to mark instead of 30;
- to let students experience the flavor of teamwork., most of the time this is done by just throwing students in teams in an ad hoc manner or just letting students form their own teams, resulting in very bad teamwork experiences, especially for the more talented students.

To enable students to experience teamwork in a more favorable setting, this paper proposes a system whereby students are trained to be effective members of a team as well as being effective leaders. There are very few activities geared towards similar goal. Notably, Chesney’s [2] work on “students’ reflection on group work” is one such activity. In [2], four 30-minute discussions, Chesney’s so-called “vignettes”, are given in a semester. Similar to the proposal described herein is the inclusion of a teamwork component in the project for their course in software design and coding. A fundamental difference is the absence of emphasis on teaching alignment. Our own experiences and anecdotal evidence show that programming assignments set by lecturers in many Australian universities are such that students do not even know how to start, which reflects the lack of alignment in course curriculum and assessment. This may explain why students in [2] did not find the teamwork training component beneficial. Instead they preferred that the time and effort spent on teamwork tutorials be allocated for the actual course material (which is software design and implementation).

Another major difference is Chesney’s lack of utilization of education technology for their teamwork training. Instead they still employ face-to-face meetings on weekly intervals, a very stressful and time-consuming affair, especially for those who work and live far away. The proposed system reported in this paper places great emphasis on the use of “chat” and
“discussion board” facilities of WebCT to enhance teamwork performance. In fact, J. Patel et al [3] conducted a survey in their work on “students’ perspectives on the impact of web-based discussion forum on student learning” and it was shown that students responded favorably to online discussion forums on their learning in on-campus courses. “Based on the positive results from the survey and the statistical analysis, it is the authors’ belief that student learning, performance, and engagement in engineering technology on-campus courses are enhanced through the use of online discussion forums” [3]. The impact would be much more significant on teamwork as it dissolves the problems of travel (especially traveling long distance, a teamwork obstacle) and common meeting time (another teamwork obstacle).

Lingard et al’s [4] study examined factors such as “gender, age, cultural diversity, previous work experience, and the degree to which work is equitably shared among team members as possible factors affecting” the success of teamwork. The findings from this work are:

- “team process effectiveness was the major factor accounting for the success of group projects”;
- talented / “good” students teamed together contributes to high quality projects;
- there may exist “a significant correlation between group synergy and project performance”; and
- there is no correlation between any of the factors (listed at the beginning of this paragraph) such as gender, age, etc. and team performance.

Following their findings, Lingard et al made some suggestions to address the problems associated with the findings. A significant number of these suggestions are very time-consuming, the very obstacles that we, as lecturers should avoid so as not to put unnecessary stress on our students. For example, team retreat, team meetings and team meeting reports, and role play are all very time-consuming affairs that ACU students will not appreciate. Unlike our proposal herein, virtual meetings through WebCT “chat” and “discussion board” were never mentioned; aligned teaching was not mentioned either but both are means for maximizing the effectiveness of teamwork as well as saving students time and effort. Like Lingard et al’s work, most of the studies in literature are about teamwork issues whereas this paper addresses students’ lack of teamwork knowledge by incorporating teamwork training in a subject which requires teaming to work on a project.

WebCT’s “discussion board” is particularly beneficial. Unlike face-to-face meetings, students have the opportunity to think and reflect on what they want to say before posting their contribution on WebCT’s “discussion board”, thus enabling them to make quality discussions. Furthermore, any contribution on topics discussed via the “discussion board” will remain for the duration of the semester making it possible for students to obtain concrete references to team members’ viewpoint in writing. This can be done whenever and wherever it suits the students.

3. Team Work

A recent survey of a class of 40 ACU students shows that 95% of students like teamwork because of shared workload; however, only a few students are able to point out the problems associated with teamwork. The 5% of students who give a definitive “no” to teamwork describe
some realistic problems associated with teamwork and these are the top students of the class, who can work solo and do well.

3.1 Teamwork Problems

Various problems associated with teamwork are:

- geographical incompatibility with team members living far from each other as well as far from the university;
- incompatible personality amongst members;
- teams with one member dominating, wanting his / her way most or all of the time;
- teams with some or most members wanting just to be “passengers” resulting in one member taking on the whole workload;
- teams with leader / members unable to resolve conflicts;
- teams with slow-start habit with most team members;

The first of the above-mentioned teamwork problems can be resolved by utilizing e-technology such as “chat” and “discussion board” facilities in WebCT. Instead of face-to-face meetings, team members can utilize “discussion board” for discussing issues related to their project. The rest of the teamwork problems can be alleviated through careful assignment of team members as well as constant monitoring of each team’s progress.

3.2 Team Formation

“Most cooperative learning models call for teachers to create groups and select members according to criteria that maximize diversity of learning styles, gender, race, culture, achievement, and other relevant qualities” [5]. Even though team formation problems have been studied since the 1980s [6], personal experience and anecdotal evidence show that team formation in tertiary education has been given very little consideration whenever teamwork is incorporated in a course. Most of the time teams are formed by students, which results in a significant number of bad experiences for students, sometimes even sad ending such as fighting and in extreme cases violence. To make teamwork beneficial to students, the software called Team-Maker (by Layton et al [1]) for student team formation is used for assigning members to teams for this MATLAB and teamwork course.

Team-Maker is the student team formation software designed by Layton et al. It assigns students to teams employing “instructor-defined criteria, including criteria consistent with the cooperative learning literature” such as “diversity of learning styles, gender, race, culture, achievement, and other relevant qualities” [5]. In order to determine each member’s attributes, students are required to complete surveys. These surveys are strictly confidential. As such, the software has two web interfaces; one for instructors’ use and the students use a different interface. Apart from designing an instrument for facilitating effective team formation, Layton et al have incorporated Team-Maker into CATME (a peer evaluation tool); the resulting software is one that forms teams as well as evaluates peers. Figure 1 shows evaluation results by peers. These results give insight into the level of involvement of each team member in the project, thus facilitating early
intervention when problems are sighted. For example, if a team or a team member exhibits “slow start” behavior, the instructor can intervene by interviewing the members of the team or a particular team member, respectively.

The CATME software enhances teamwork through the following:

- data from students are gathered from a web interface to ensure “confidentiality of peer ratings”;
- the above data are analyzed by the system to calculate equitable grades for each team member; and
- extensive feedback to the faculty regarding the characteristics of each team member as well as each team (refer to Figure 1).

The CATME system has modules for the protection of passwords. It also has modules for reporting. There is an administration interface which allows the administrator to monitor faculty members’ access to the system. This interface also provides access to raw data gathered from surveys. Faculty members use the faculty interface for the following:

- to provide information about their classes;
- to assign students to these classes;
- to conduct surveys for team activities;
- to control student instructions;
- to control the content of surveys and

Figure 1: CATME student peer evaluation results (taken from [1]).
Most students tend to procrastinate with their assignment tasks, leaving insufficient time to perform well. To solve this “slow-start” problem, students need to show evidence that they are working on their assignment tasks continuously via discussion board in WebCT, from week 1. Furthermore, they also have to submit reports every fortnight on what they’ve done, as well as problems they have encountered. These reports have to come from each student and peer-assessment of team members and the progress on teamwork must be included in the reports. To encourage students who are motivated as well as talented, bonus marks are given to students who contribute the most and who offer peer support to those who are less motivated / talented in the subject. This would make the top students happy with teamwork as these are the students who do not like teamwork. The comments each of them gave in the survey was: “I always ended up doing most if not all the work whilst others were just given the marks without doing much, it is so unfair!” This bonus-marks system works extremely well in the subject, “Hardware and Operating Systems”, a subject that we’ve run for the last three years in ACU.

No matter how well students have been trained in teamwork, if there is lack of teaching alignment students will not perform well in the project due to the following:

- the key reason for poor performance is “slow start” because if students have not been taught the topics for a task, they cannot start and if the topics related to the task are left till the middle or the end of semester then students can only start in week 6 or 12 respectively; and
- when students look through the assessment tasks, if they find that they do not understand, some become very anxious, others just give up.

4. Aligned Teaching with Progressive Assessment

“In aligned teaching, assessment after teaching has been completed is conducted to tell us how well students have learned what we intended them to learn and at what level” [7]. This can only happen if the teaching / learning activities are such that they focus on the curriculum objectives which in turn should be strongly embedded in the assessment tasks, as depicted in Figure 2. For assessment to be formative, facilitating feedback to students to nurture improvement such that students will perform better in the future, the assessment tasks would have to be progressive / continuous. These tasks can be weekly short WebCT quizzes, fortnightly short reports, and short written tests.

![Figure 2: Aligning Curriculum Objectives, Teaching and Learning Activities, and Assessment Tasks](image)

“If the curriculum is reflected in the assessment, …, the teaching activities of the teacher and the learning activities of the learner are both directed towards the same goal” [7]. To this end, we have designed a system for teaching an introductory course in MATLAB, which features a very
strong alignment of curriculum objectives to assessment tasks; refer to Figure 3 where the arrow pointing from “objectives” to “assessment” implies the objectives of the course must be embedded in the assessment tasks. The proposal for this system is reported in the next section.

![Figure 3: Perspectives on Assessment from Teacher’s and Student’s Viewpoints (adapted from [7])]()

5. The Proposed Project

In order to foster strong alignment between teaching curriculum and assessment, a large assignment is divided into 6 different tasks, which also facilitates formative assessment. Formative assessment gives students opportunity to obtain feedback on their mistakes, as well as enabling them to seek improvement to their performance with the next task.

5.1 MATLAB Project

Task 1: read and understand issues in teamwork then show this understanding by writing a report to be handed in at the end of week 3.

Task 2: 15 audio multicast traffic traces, from [8], will be posted in WebCT. These matrices will be identified with file names which are the names of machines receiving these traces - students need to go through and understand these traces.

Task 3: students will have to strip all columns off except the column with the packet numbers so that the matrix becomes a vector looking like Figure 4.

Task 4: write program codes to find the number of isolated packet losses as well as consecutive packet losses. For example, in Figure 3 (showing the packet stream received by lupus in Germany), a 2-consecutive packet loss is witnessed in the loss of packets 2 and 3. An isolated loss is packet 6.

![Figure 4: Packet Stream Received by lupus (a machine name).]
Without losses the packet stream should arrive at the destination like the packet stream shown in Figure 5.

![Figure 5: The Original Packet Consisting of 45000 Packets](image)

**Figure 5: The Original Packet Consisting of 45000 Packets**

Task 5: write program to change the packet stream depicted by Figure 4 into the one shown in Figure 6, giving a vector with 0s and 1s. The 0s are the lost packets and the 1s represent the received packets.

![Figure 6: A Vector Consisting of 1s and 0s](image)

**Figure 6: A Vector Consisting of 1s and 0s**

Task 6: compute the cumulative distribution of losses of each traffic trace and create graphs similar to Figure 7. This is undoubtedly the most challenging of all the tasks, particularly for those who are not mathematically inclined. 5% of bonus marks are allocated for this task to motivate students to participate.

![Figure 7: Cumulative Distribution of the Packet Losses of the Machine Named cedar](image)

**Figure 7: Cumulative Distribution of the Packet Losses of the Machine Named cedar.**

“The ability to work well in a group is a required skill for success in the workplace. However, it is also a skill that is seldom taught in the academic environment. Often, students are asked to function in project groups without any training or experience on how to do so” [2]. As such, this paper proposes a teamwork project in a subject that introduces the MATLAB programming language and included in this subject is a component that trains students to work successfully in teams. Detailed weekly schedules are described here to show how teaching / learning activities are aligned to assessment tasks and also how teamwork issues are integrated in the weekly activities.
5.2 Schedule: Matlab & Teamwork Training Lessons

Week 1
- Lessons on some basics of MATLAB so that individual work can begin on the project;
  - History of MATLAB, including why use MATLAB
  - Go through some useful commands such as how to enter numbers, vectors and matrices, and
    assign them to variables; and
  - How to use MATLAB commands such “save augustssession3”, and “load augustssession3”.
- Some basics of teamwork (such as the characteristics that can make a dream team come true); refer students to websites with good articles on teamwork and encourage them to do some research on teaming. Setting an assessment task (discussion participation in WebCT and handing in a report on teamwork at the end of week 3) would give them motivation to get them working in week 1.

Week 2
- More on MATLAB targeting at students being able to perform tasks 2 and 3 of the team project, such as how to use “load” in MATLAB to access the traffic traces (in matrix form) so as to strip off all columns of the matrix except the packet numbers.
- The “if statement” will be introduced this week together with the “for-loop” and “nested loops”. This would enable students to write a program for tasks 2 and 3.
- Explain how loop and branch statements can be nested.

Week 3
- More on MATLAB “if statement” and loops ensuring that students are ready for tasks 2 and of the project.
- Manipulation of matrices
- Discussion on teamwork with emphasis on student contribution in lectures, that is, students have to talk about what they have read so far.

Week 4
- MATLAB graphics such as how to use “plot”
- How a team is formed: students are referred to a team building and teamwork website [9]. Students are also encouraged to do their own research on teamwork.
- The article, “Friendship and choosing groupmates: preferences for teacher-selected vs. student-selected groupings in high school science classes” by Mitchell et al is posted on WebCT and everyone has to read and make intelligent discussion in class. Teams are formed with the help of:
  - Discussion contributions in WebCT;
  - Individual reports submitted in week 3;
  - Tutorial and lecture participation; and
  - Team-Maker by Layton et al. (information collected from the above 3 items are used to correlate with information gathered by the confidential surveys completed by students via Team-Maker)
Week 5
- Geometric distribution and more on MATLAB graphics
- Discussion on teamwork problems, emphasizing on “slow start” and its consequences.

Week 6
- Probability distribution of a geometric random variable.
- More discussion on teamwork problems emphasizing on bonus marks for offering peer-support to students who are slower in understanding MATLAB and teamwork concepts

Week 7
- Cumulative distribution of a discrete random variable.
- “The seven characteristics of a dream team” [9]:
  - shared values;
  - complementary skills
  - well-defined working goals;
  - meaningful purpose;
  - clear performance goals;
  - mutual accountability; and
  - small numbers.

The last characteristic is achieved by teams having been formed with 3 members only, thus the discussion will be on how to achieve the rest of the characteristics.

Week 8
- Lectures on how to plot cumulative distribution of the consecutive lost packets of the traffic traces, formula given.
- Discussion on how to resolve conflicts in teamwork as it is anticipated that this will be the time when teams have conflicts. University life in the last few weeks of semester is packed with stress and tension as there are a lot of assignments due and exams are just round the corner.

Week 9
- Revision of the topics discussed in the previous 8 weeks, illustrating each topic with more difficult examples, in particular, the “nested loops” concept and the derivation of the cumulative distribution of audio packet losses. By now, the students are ready to do all the 6 tasks.
- Discuss “why teams do not perform”, that is, knowing and understanding the barriers to good performance

Week 10
- Some discussions on MATLAB graphics such 3D graphs.
- Interactive discussion on common problems in teamwork, requiring all class members to participate so as to encourage sharing of their teamwork problems, if any.
Week 11
- Lectures on matrix-matrix products and common functions in Matlab.
- Revision on topics required for the MATLAB project.

Week 12
- Revision of the whole course; MATLAB and teamwork issues, giving emphasis on topics that will be in the final exam.

Table 1 shows the alignment of teaching / learning objectives to the assessment tasks, week by week.

<table>
<thead>
<tr>
<th>Week</th>
<th>Teaching / learning objectives</th>
<th>Individual Assessment tasks</th>
<th>Team assessment tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- MATLAB basics</td>
<td>Discussion participation via WebCT on teamwork issues</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>- issues in teamwork</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 2    | - more advanced commands on matrices in MATLAB  
      | - the “if statement”, “for loop”, nested loops, and how the loop and branch statements can be nested | More interactive discussion via WebCT on teamwork issues | None |
| 3    | Manipulation of matrices     | -WebCT quiz on teamwork issues covered so far  
      |                             | - 1st report on Matlab project (task 2) due | None |
| 4    | - MATLAB graphics such as how to use “plot”  
      | - discuss issues on team formation | -WebCT quiz on MATLAB topics covered in weeks 2 and 3 | None |
| 5    | -Geometric distribution &  
      | Matlab graphics              | -10 minutes WebCT quiz on MATLAB topics covered in the last 2 weeks  
      | -slow-start problem in teamwork | -30 minutes written test on teamwork | WebCT discussions on why teamwork fails |
| 6    | -probability distribution of a random variable  
      | -teamwork issues on conflict resolution | -10 minutes WebCT quiz in MATLAB topics covered so far  
      |                             | -2nd report on Matlab project due | - WebCT discussions on tasks 1 and 2.  
      |                             |                             | - team report (on tasks 2 and 3) due |
| 7    | -cumulative distribution of a discrete random variable  
      | -cultivate teamwork characteristics | -10 minutes WebCT quiz in MATLAB topics  
      |                             | -10 minutes WebCT quiz on teamwork issues on conflict resolution | WebCT discussions on task 4 |
| 8    | -plotting graphs in MATLAB  
      | -how to resolve conflicts in teamwork | -10 minutes WebCT quiz in MATLAB topics related to tasks 2, 3, & 4 | - WebCT discussions on topics related to tasks 2 to 4.  
      |                             |                             | - team report on task 4 due |
| 9    | -revision on MATLAB topics  
      | emphasizing on the topics that are related to the project tasks | -10 minutes WebCT quiz on MATLAB topics covered so far  
      |                             | -30 minutes written test on teamwork covered in week 7 | WebCT discussions on tasks 5 and 6 |
The introductory course for MATLAB programming runs for a semester. In order to maximize the effectiveness of learning this course, students will be giving continuous / progressive assessment as shown in Table 1. The tasks given in Table 1 are aligned to topics taught in each week. For example, after week 2 lectures and lab exercises, students will know enough about the MATLAB language to work on tasks 1 and 2, thus producing a report on the progress of the project. This report should also contain information about teamwork covered in week 1.

Both the schedule and the continuous / progressive assessment tasks have been carefully designed to align to the tasks prescribed for the project:

- weeks 1 and 3 teaching / learning activities enable students to perform task 1 of the project;
- weeks 1 and 2 teaching / learning activities aim at tasks 3 and 4;
- weeks 1, 2, and 3 teaching / learning activities will provide students ability to do tasks 4 and 5; and
- weeks 1, 2, 3, 4, 5, 6, 7, and 8 teaching / learning activities train students to perform task 6.

6. Conclusion

This paper proposes a method of training team members to share the responsibility of working on a MATLAB project. It is anticipated that with constant reminders in the form of assessment tasks on teamwork issues students will be less likely to be “passengers”.

“The greatest enemy of understanding is coverage…” [7] Besides ensuring that there is strong unambiguous alignment between teaching / learning activities, curriculum objectives, and assessment, the content for the introductory course to MATLAB has been carefully assessed as not being too much for the students to learn as the teamwork training component has taken a significant portion of the time allocated to the course. Otherwise, students will refuse to take the teamwork part of the course seriously, resulting in not gaining any benefit from the teamwork training.

A key feature of this proposal is rewarding (giving bonus marks of up to 5%) students who show evidence, via WebCT discussion board and assessment tasks (such as written reports, and online quizzes) as well as peer-evaluation from CATME, that they are contributing more to the project and that they are also helping students who are slower in understanding MATLAB and teamwork.
issues. This reward scheme serves as incentive to make their teams work and to offer support to less-able students, creating a caring peer-support environment in this course.

It is hoped that the teaching / learning system proposed in this paper would conform to Ramden’s learning theory: “… learning in educational institutions should be about changing the ways in which learners understand, or experience, or conceptualize the world around them. The “world around them” includes the concepts and methods that are characteristic of the discipline or profession they are studying” [10]. In this study, “the world around them” includes knowledge in MATLAB and teamwork. After taking this subject, apart from gaining knowledge in MATLAB, students’ experience and concept of teamwork would be transformed. That is, the top students should feel that teamwork is not as bad as they thought and for the “passengers”, contribution to teamwork project should be deemed as a rewarding experience.

Human nature as it is, it is hard to expect students not to “revert to form” in the absence of the checkpoints provided by the proposed framework. As such, faculties in universities worldwide should be encouraged to use the combined CATME / Team-Maker software system for running courses with teamwork components. This system can monitor how successful or unsuccessful teamwork is in any course thus facilitating early intervention when required.

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