Capstone Project Course Framework and Individual Grading Formula

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ABSTRACT

Final stage students at degree and graduate diploma level undertake a capstone project course as part of their study. The expectation from students is to develop an industry IT product, in addition to the academic requirements of the programme, utilising skills such as teamwork, planning milestones, meeting deadlines, reporting on progress and presentation, which add further complexity to the project. This paper presents a framework for the delivery and assessment of a capstone group project, as implemented and refined over the last five years, in particular considering the parallel assessment of the technical and soft skills learning outcomes of the course. The framework covers process, product and soft skills, each of which involves group and individually assessed milestones. This paper describes how these components overlap and interrelate, and proposes a formula to allocate individual marks for group work based on individual effort, solving a commonly reported problem of individual underperformance in team work. Both framework and formula could be applied to any group project.

Keywords: capstone project, project courses, assessment, information technology.

1. INTRODUCTION

IT capstone project courses provide students with the opportunity to apply learning from their studies to real world problems. Students of Bachelor of Information Technology (BIT) and Graduate Diploma of Information Technology (GDIT) at Auckland Institute of Studies are required to complete an industry capstone project course in the final stage of their study. The value and aim of capstone project courses is to provide students with the opportunity to integrate, reinforce and extend existing knowledge, as Mann & Smith (2006), Goodwin & Mann (2007) and Albakry & Paynter (2011) note, and to gain experience of working within a team. Many employers desire or even require evidence of the ability to work in a team, as well as communication skills, as noted by Hagan (2004) and Pais (2012).

Assessment of such team project courses is not straightforward as the projects vary between groups, and individual team-members make varying contributions to the projects. A need has been identified for assessment tools that assess not only the intended outcome of a course but also the information technology aspects of the project and the teamwork skills of each member of the team (Biggs, 1999; Lister & Leaney, 2003; Hayes, Lethbridge & Port, 2003; Box, 2004). Clark, Davies & Skeers, (2005) and Kulturel-Konak, Konak, Kremer, Esparragoza & Yoder (2014) recommend using peer assessment of students and both describe the use of web-based tools to facilitate such assessment. Kearney (2013) emphasises the importance of using both formative and summative assessment, and the benefits of peer assessment, particularly as part of life-long learning. He stresses that in assessment, "the paramount focus must be on enhancing students' capacity for learning and engagement with the curriculum" (Kearney, 2013, p. 887). Kearney (2013) suggests a model of assessment that focuses on self and peer assessment, in which the student, two peers and the lecturer mark each student's submission and they all contribute to the summative grade.

There are a number of commonly reported problems in any group assignment. As numerous authors note, Brown (1995), Kaufman, Felder & Fuller (1999), Clark & Baker (2011), Clark et al (2005) among them, students are understandably concerned that their contribution to the team project will not be accounted for fairly, or that team members who do not contribute equally will diminish the grades of the entire group.

Vanhanen, Lehtinen, & Lassenius, (2012) describe that capstone project students often lack team-building and people skills. Passing the course and learning does not motivate team members equally enough to ensure they all contribute equally to produce the expected outcome. There is also a risk in peer assessment, as Kulturel-Konak et al (2014) indicate, that some students will inflate the grades of their group members, or conversely ill-feeling will cause students to deflate the grades of team members. Moreover, as Oakley, Felder, Brent, & Elhajj (2004) warn, the benefits of team projects are not automatic, and the frustration and resentment which can arise from being in an ineffective team may, in a small number of cases, outweigh the benefits of team projects.

2. PROJECT SOURCES AND DELIVERY PROCESS

The project topics are sought by staff from IT companies prior to the start of the semester, falling mainly into categories of networking and software development. The project level of difficulty is assessed and scope cut-off may be applied if necessary. In addition, each project is expected to capture students' and supervisors' interest, being challenging but yet achievable.

For both BIT and GDIT students, the project course carries the same number of credits and level of difficulty, however it is spread over 26 weeks for BIT students and compressed into 13 weeks for GDIT students. During the first week presentations are conducted by potential project clients regarding available projects. Students prepare their CVs and submit three choices in order of preference. Project groups normally have three to four students, and teams are formed by the course coordinator to ensure uniformity of team level and skill combinations. The course coordinator matches

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applications with projects and allocates supervisors, taking account of project complexity and students' abilities.

All project students, supervisors and the course coordinator meet frequently as a group, each team presents project progress, discusses challenges and possible solutions. Each supervisor is required to organise a weekly meeting with their project team. Supervisors check each student's weekly journal and peer evaluation forms to ensure each student is actively participating. Supervisors may change task allocation to ensure that each team member equally contributes to all components of the project course.

The project client normally designates a dedicated person (mentor) from their organisation to coordinate with and provide relevant support to the project group during the whole development cycle. Contact, either face-to-face or via e-mail, is made at least weekly to report progress and discuss issues. A record of these contacts are part of the project documentation. At the end of the semester, project teams demonstrate their systems to their peers, supervisors and course coordinator. Feedback is given during presentation time.

Although the client mentor is not involved in marking the projects they do provide a report which is used as a factor in deciding the final product grade, but the responsibility for teaching, assessment, and recording of marks lies solely with the project supervisor.

3. STAKEHOLDERS' ROLES

The project course involves the following parties

1- Course coordinator: oversees the course, seeks projects from clients, assesses project difficulty level, form teams, allocates

projects to students and supervisors, monitors teams' progress and performance, and maintains all teaching materials including, assessment marking schedules and project process documents to be used by all supervisors.

2- Project supervisor: for each team the course coordinator allocates an academic staff member as a supervisor, who monitors students' contribution and progress throughout the project. The project supervisor is also responsible for providing technical advice and direction, as well as marking all submissions for grading.

3- Project team: each team consist of three to four students. The team will nominate a project manager, who must be approved by the supervisor. The project manager's role is to distribute work between team members, maintain project progress, manage risk, coordinate team meetings and communicate with the client. Project manager duties are closely monitored by the team supervisor to ensure equal and fair contribution. Each team member including the project manager is expected to contribute to each component of the project.

4- Client mentor: The client usually designates a representative from their organization to coordinate with and provide relevant support to the project team during the whole development cycle. Contact face to face and via e-mails are made to report progress and discuss issues. Project team are required to seek client approval for their end product acceptance.

4. PROJECT COURSE MILESTONES

The project course includes a set of deliverables and milestones, which are developed to assess the learning outcomes of the course and monitor the product development process. The progress monitoring creates an environment to consistently provide students with feedback and highlight concerns that could affect the outcome of the course and/or client satisfaction. Table 1 shows the main milestones of the project course academic requirements, their weightings and week due. The table shows that marks are mainly allocated to reports and the product as academic and technical deliverables, both of which involve soft skills and project development process coverage.

Table 1: Project course milestones summary

No	Description	Weighting	GDIT week due	BIT week due
1	Proposal report and presentation	10%	W3	W3
2	Initial system requirements specifications (SRS), analysis and application design	20%	W5	W6
3	Prototype presentation, the expected prototype is a working model that demonstrates the main project functionalities. The prototype must be presented to the client to get client sign-off	Progress monitoring Formative assessment	W8	W9
4	Project final report	15%	W12	W25
5	Final product (application / system tested according to the initial requirement, and approved requirement change	30%	W12	W25
6	Final presentation of the product	10%	W13	W26
7	Journal and reflective learning report	15%	W2 –W12 Weekly	W2 – W24 Fortnightly
8	Informal presentations		At least 5	

5. FRAMEWORK

5.1 Framework Overview

Figure 1 shows the project course framework overview. The framework was built with a focus on assessing project milestones, and has been refined over a period of 5 years, through experience as well as feedback from supervisors, industry clients and student surveys (Albakry, 2011). The framework addresses the following areas:-

- Student grades are obtained by considering the following three areas for each project deliverable (project milestones).
- *What*: Covers what area each milestone assesses, the three main components used for the industry project are product, process and soft skills.
- *How*: Covers how to assess each milestone. The assessment method could be summative, formative or a combination.
- *Who*: Covers who will conduct the review or marking of each milestone progress and provide feedback or award marks for the final version. This could be the supervisor, other academic staff member, peer or self-assessor.

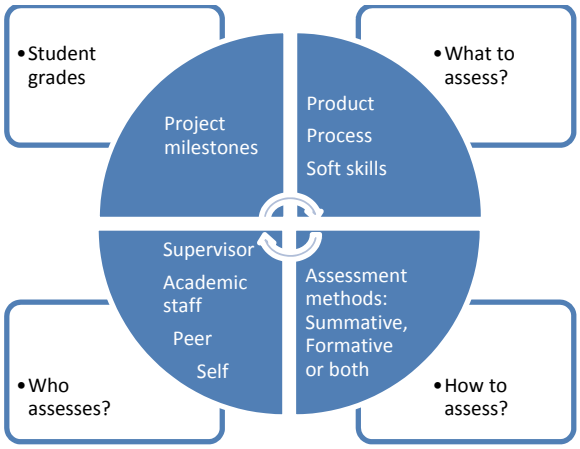

Figure 1: Project Course framework overview

Figure 2 shows further details of the three components used for our industry project under the *What to assess* area, these components will be used as a basis for our assessment criteria;

- Product development, which includes a physical product that provides a solution to the client's problem, such as software, hardware or data model, and academic documents such as proposal document, analysis report, presentation slides, journal and learning reflection report and final report. All students are expected to contribute to each component under this section, however the percentage of individual contribution could vary across the different aspects of the product.
- Process, which focuses on the project management. The project manager is expected to plan and manage the whole project and each individual is to plan her own tasks.
- Soft skills development, which is planned to develop the student's self-motivation, self-management, problem-solving and oral presentation skills. It also promotes effective communication and team conflict management.

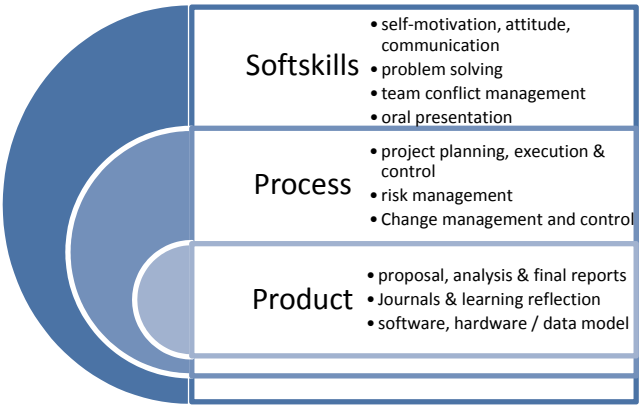

Figure 2 project framework, *What to assess* area

Due to the dynamic nature of IT projects, with evolving requirements and interrelated components, the academic documents must be considered as live documents. While these documents are expected to be submitted as scheduled during the semester, all are marked for grading at the end of the semester. However feedback is provided to students frequently, at least weekly at meetings and with comments on student journals. The depth of feedback varies depending on the project complexity level and the student's competency and need.

One of the main learning features of our industry project is teamwork, which provides students with an opportunity to develop a wide range of skills such as critical thinking, problem- solving and time management. In addition, team work develops students' ability to provide and receive constructive feedback. However, problems were consistently reported with the attitude of a small number of individuals that could negatively impact the outcome of the team effort, which highlighted the importance of identifying assessment techniques that reward individuals based on their own contribution.

The team must agree to what needs to be done each week, and the project manager allocates duties to each team member; thereafter each individual is responsible for his own task. The task allocation is recorded in students' weekly individual journals as part of the learning reflection.

5.2 Assessment Tools

This section covers the *How* and *Who* areas of the project framework. The project supervisor, client representative and the team, all play important roles that lead to the desired project outcome. The supervisor may suggest techniques and technologies tailored for each project. However, project management activities are conducted by the team, and the interaction between the project manager and the client is critical to ensure the outcome meets the requirements.

While the supervisors are heavily involved in the process and monitoring the contribution of team individuals, the students themselves produce the project milestones, therefore it is essential to get them involved in the assessment process as peer or self-assessor (Clark et al, 2005).

The project assessment tools involve both summative and formative assessment, including lecturer, self- and peer-assessment and are designed to help students discover, integrate and maintain knowledge. Figure 3 summarises the assessment model for this industry project course. Summative assessment is completed by the supervisor at the end of the semester, following grading criteria against all milestones that hold weighting as shown earlier in Table 1.

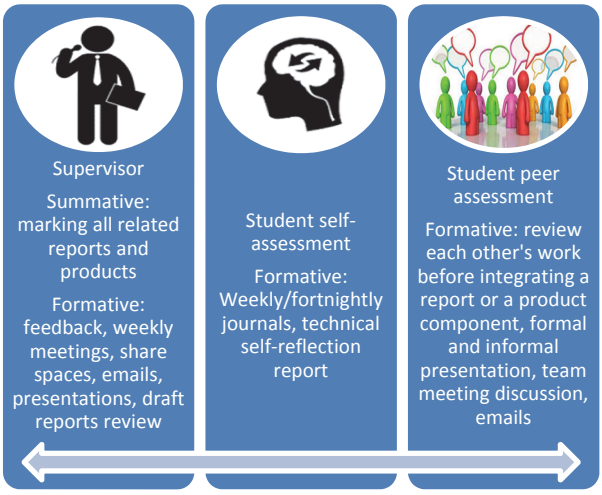

Figure 3 Project assessment tools, *Who* and *How* to assess project milestones

Formative assessments on other hand are provided by the team supervisor through supervisor weekly meeting, emails or share spaces. Other supervisors and the course coordinator may also provide feedback through formal and informal scheduled presentations. Peers provide feedback through team weekly meetings. Peer evaluation forms are also used to monitor and redistribute individual levels of contribution to the project. Students are required to evaluate other team members using the forms which are confidentially completed by students and submitted with their weekly journals. Journals are not marked for any student if they are submitted without peer evaluation forms. Students are expected to consistently reflect on their own work through the weekly journals and also the technical self-reflection report.

5.3 Project Summative Assessment

The project assessment must provide individual grades from the team project milestones. It is vital that individual grades fairly reflect contribution, avoiding problems reported in the introduction such as unfair avoidance of work. Peer assessment can help to overcome this, but can lead to grade adjustment due to personal feelings between team members. Therefore, good assessment techniques are essential to balance and manage expected individual and group deliverables, and must include both summative and formative assessment. In addition, both student and supervisor involvement is expected, as Vasilevskaya, Broman & Sandahl (2014) note, and furthermore assessing both soft skills and technical proficiency is also an expectation in the project courses.

Fortunately, as Kulturel-Konak et al (2014) suggest, peer assessment reduces the likelihood of students not performing in the group, and leaving the rest of the group to do all the work. Peer assessment also has the benefit of highlighting dysfunction within a team, so that it can be addressed early. It can also provide valuable insight for the students into how they perform in a team, which is important for future employment.

Brown (1995) identified assessment problems that appear with group work such as the difficulty of ensuring individuals contribute equally to the team. He proposed an autorating system that calculates individuals mark based on their contribution weighting, which is determined by team members.

In our model all grades lie solely with the project supervisor. The students rate their team members' contribution weekly for the purpose of monitoring and control and at the end of the project each student completes a form to specify the percentage each team member contributed to each milestone. These forms are collected for future reference and to validate the model. Students complete all forms confidentially.

All project milestones are considered and assessed as products. Table 2 shows project milestones and how they are related to the main components in our framework (Products, Process or Soft skills), the table also distinguishes group and individual tasks.

Table 2: Group or Individual Project milestones as related to the framework components

No	Description	Coverage	G/I
1	Proposal report and presentation	Product, Process & Soft skills	G&I
2	Initial system requirements specifications (SRS), analysis and application design	Product	G
3	Prototype presentation	Product, Process & Soft skills	G
4	Project final report	Product and Process	G
5	Final product	Product & Process	G
6	Final presentation of the product	Product & Soft skills	G&I
7	Journal and reflective learning report	Product, Process & Soft skills	I
8	Informal presentations	Product, Process & Soft skills	G

G/I = Group or Individual assessment

5.4 Process and Formula for Generating Individual Grades

The following steps are used to assign individual marks to group work:-

1. The supervisor marks the group reports and the product. For each assessed milestone the supervisor will allocate marks to the team (TM).
2. For each milestone:
   - The supervisor determines the individual contribution for each member (the sum of contribution of all team members should be100%).
   - Individual marks (IM) are calculated according to the following equation

$$IM = TM * \text{team member contribution} / \text{top contribution in the group}$$

3. For each team member, the overall mark will be calculated by adding her individual mark for all milestones.

For example:

The team received a mark of 24 out of 30 for the Final Product milestone (application or system)
Student A contribution was evaluated as 40%
Student B contribution was evaluated as 35%
Student C contribution was evaluated as 25%

The individual percentage contribution and the top percentage contribution will determine the individual mark as follows:

Student A = 24 * 40 / 40 = 24
Student B = 24 * 35 / 40 = 21
Student C = 24 * 25 / 40 = 15

The same is applicable on all group work components. The assessment tools are designed to promote equal contribution between team members, particularly if all students have equal contribution to a specific milestone, all student scores will be same as team mark (TM) for that milestone. This should encourage students to learn from each other, and motivate students to take on extra tasks.

For individual milestones such as presentations and project reflection report, each student will receive an individual mark based on his performance.

6. CONCLUSION AND FUTURE WORK

Capstone project courses are complex, combining industry projects, academic requirements and group work with its concomitant soft skills. Consequently the assessment of these courses is also complicated.

This paper has described a framework for capstone project courses to ease the complexity of the project course assessment, and manage factors involved in the process. The framework has been tested and refined over the last five years in an Information Technology programme. We strongly recommend the framework for any capstone project. A formula has been introduced to derive individual marks from team mark for group projects, which we suggest is also applicable for any group project regardless of the project size.

In the future we are planning to evaluate the suitability of the proposed framework for use in other programmes' capstone projects, investigate the validity of the peer assessment forms and their effectiveness for use in summative assessment. In addition we will look at the possibility of automating the process of collecting and analysing the weekly peer evaluation forms, which will reduce the workload on supervisors.

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