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Authentic Assessment Applied to Engineering and Business Undergraduate Consulting Teams*

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The rationale and structure of an authentic assessment strategy used in the multi-disciplinary industry project (MDIP) at Monash University over the last five years. The MDIP involves engineering, marketing, accounting and industrial design students nearing the end of their undergraduate programs working in multi-disciplinary product development teams of 8–10 members. The students work on real problems provided by participating industry partners. The authentic assessment strategy developed to evaluate individual student performance is based partly on group performance on both written and live presentations of their project reports as assessed by both industry partners and supervisors, and partly on the performance of each individual on a range of real-life skills as assessed by the supervisor, their peers and the students themselves. What makes the assessment 'authentic' is that the problems provided by the industry partners are real and the skills that are assessed during the completion of the project are essential for participation in multidisciplinary project teams that operate in modern industrial settings.

INTRODUCTION

TRADITIONAL ASSESSMENT via written exams is still the preferred method of assessing students in many, if not most, engineering courses. While this may be justified for assessing acquisition of specific knowledge and intellectual skills, it is of doubtful validity as a means of assessing students' ability to apply that knowledge to real situations and is even less valid for measuring many of the real-world skills which graduates are expected to perform in the workplace. After a brief account of the educational rationale of the multidisciplinary industry project (MDIP) at Monash University in Melbourne, Australia, the paper outlines the components that make up the authentic assessment strategy to measure individual student performance in the team project.

Each year since 1996, students in the third year of Industrial Engineering, Accounting, Marketing and Industrial Design at Monash University have worked as product development consulting teams for manufacturing companies. Multidisciplinary teams of 8 to 10 students are formed to provide a wide range of skills, enabling all aspects of product development including market surveys and strategies, product design, development of manufacturing and assembly strategies, quality control procedures etc. to be developed, all within the limitations of available finance and for a competitive cost. Since there is no specific body of intellectual content forming the curriculum for this subject, the multidisciplinary team project-based learning strategy makes formal exams inappropriate, and it was necessary to develop an alternative assessment strategy to evaluate individual student performance. The type of approach adopted is often referred to as authentic assessment.

AUTHENTIC ASSESSMENT

The term 'authentic assessment' is relatively recent in the lexicon of educational practice. A scan of the literature available on the worldwide web indicates that it is most commonly associated with language and writing development programs, school-to-work transition curricula and in some science and mathematics education programs. However, the term 'authentic assessment' is appropriate for any type of assessment that requires students to demonstrate skills and competencies that realistically represent problems and situations likely to be encountered in daily life, or where students are required to complete tasks that have real world applications [1]. Authentic assessment in effect refers to a whole way of thinking about the assessment of students who are working within an integrated/contextual-learning environment where they are developing generic life-long learning and real-world problem solving skills [2].

An authentic assessment strategy embodies a whole raft of alternative or non-traditional assessment techniques. Alternative approaches are needed because traditional forms of assessment (paper and pencil tests such as essays, multiple-choice questions, algorithm-stuffing problems, written assignments) with their focus on the recall comprehension and application of specific,

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usually single discipline-based, knowledge are inappropriate and of doubtful validity as a means of assessing students' ability to apply that knowledge to real situations and are even less valid for measuring many of the real-world skills which graduates are expected to develop over the duration of their courses.

Authentic assessment strategies employ a range of assessment techniques:

- performance evaluations;
- criterion referenced appraisals;
- systematic observation by instructors, clients, peers, self;
- portfolios and journals.

These are linked directly to desired learning outcomes. So the concept of authentic assessment clearly has its roots in performance testing, particularly of work skills requiring error-free performance of complex psychomotor and cognitive tasks with speed and accuracy. It also has its roots in criterion-referenced assessment where the assessment task is linked directly to desired or expected learning outcomes expressed in objective terms—where the level of performance is related to demonstration of specific behaviors (what has to be done), the conditions under which the task is to be performed and the level of performance expected [3]. Thus one would expect authentic assessment to be an integral component of courses employing a constructivist paradigm for teaching and learning [4, 5].

Alternative forms of assessment are no less prone to shortcomings of design, administration and management than are the more traditional pencil and paper tests. Many of the issues are the same:

- corruptibility;
- security;
- the efficacy of tests as a motivator for learning;
- equity issues;
- psychometric issues such as reliability;
- sampling;
- validity;
- discriminating ability.

These need to be addressed to ensure the credibility of the reported assessment outcomes [6].

SHORTCOMINGS OF ENGINEERING EDUCATION

Much has been written in the last decade or so about graduates from university courses in engineering and business lacking:

- skills in communication, decision making, leadership and problem solving;
- ability to work with people from different backgrounds;
- flexibility and ability to cope with ambiguity.

In the USA, for example, a report by the American Council on Education revealed that 9 out of 10 graduates believed that their degree did not help their workplace performance, that graduates were deficient in communication and teamwork skills, were inflexible and unable to cope with ambiguity, and could not work effectively with people from different backgrounds. Elsewhere the report indicates that US business requires graduates to be better skilled in cross-functional teamwork where team members showed significant diversity. Other required skills included decision-making, creativity, project management, continuous learning and leadership. The report also noted that traditional education tends to emphasize well-structured problems with clear solutions, but that real-world problems are not so well structured, and require solution strategies that are intuitive and speculative [7]. It is quite clear that Engineering Criteria 2000 is a direct response to this type of criticism.

Likewise Finiston [8], Wearne [9], Williams [10] and Johnson [11], reviewing engineering education in Britain and Australia concluded that engineering courses fail to provide graduates with the skills which industry, professional associations, governments or indeed the graduates themselves consider necessary. Johnson [11] notes that:

> Engineering education must become more attuned to the real concerns of communities. Courses should promote environmental, economic and global awareness, problem solving ability, engagement with information technology, self-directed learning and life-long learning, communication, management and teamwork skills.

Engineering is not alone in facing these challenges. Davis & Broadbent [12] note similar issues with Industrial Design courses and Albrecht [13] and Kuczynski [14] report similar concerns with business education.

So, there seems to be fairly wide agreement in the literature about the things that need to be included in university courses to better-fit graduates to real-world experience. Indeed, if one looks at engineering and business course outlines most would claim that all or some of these skills are high on the course agenda. Yet the outputs of programs continue to be criticized because the graduates emerge deficient in these important skills. The solution in part is seen to be putting less emphasis on lecturing and the acquisition of discipline-specific knowledge and to experiment with instructional methods (such as having students work in cross-disciplinary teams on unstructured problems) where the students are more active participants in the learning process. Another part of the solution is to broaden assessment strategies so that they are less reliant on knowledge recall and highly structured problem solving algorithms. Assessment programs reflect the values placed on different components of a program—those that are not assessed are not perceived to have value.

THE MULTIDISCIPLINARY INDUSTRY PROJECT

The multidisciplinary industry project (MDIP) has been developed by a team of academics at Monash University (two engineers, two marketers, an accountant, an industrial designer and an educational technologist) as a deliberate attempt to address as many as possible of the shortcomings, highlighted above, within the context of a semester length study unit. The MDIP did not simply materialize out of thin air but has grown out of the collective experience of the team over many years of attempting to more adequately address the issues of making the university learning experience more relevant and meaningful in terms of later work-place experience. Some of the antecedents and their influence on the MDIP are described in Appendix 1 at the end of the paper. The MDIP has now been offered to a class of about fifty students each year since 1996.

The rest of this paper briefly describes what has been done in the MDIP to establish an appropriate learning environment to foster the development of the desired real-world skills and the assessment techniques that have been used to provide a credible authentic assessment regime.

Theoretical Basis for the MDIP structure

The MDIP takes place in a learning environment based on key features of 'problem-based learning' as described by Boud and Felleti [15], Woods *et al.* [16], Johnstone and Biggs [17], 'action learning' as outlined in Revans [18] and Mumford [19], and 'cooperative learning' outlined in Ravenscroft *et al.* [20]. It pays particular attention to the development of the competencies needed to enhance present learning and develop life-long learning skills.

The MDIP also draws on the work of Slavin [32] and Ford's Theory of Motivational Systems as developed by Pintrich and Schunk [33] which indicates that high levels of motivation and achievement can be attained in a learning environment where:

- individuals work in groups to develop and attain their own goals;
- goals are clear, and multiple goals are employed;
- feedback is relevant and prompt;
- tasks are challenging and realistic.

Practical implementation of this body of theory requires:

- The learning activities take place within a context that is meaningful to the student.
- The learning approach should place responsibility on the students to determine how to apply existing knowledge and how to go about finding out what they do not know.
- The type of problems students are asked to solve should affirm that learning is neither content free, nor is it entirely process oriented, and that different disciplines have different ways of dealing with information and knowledge.
- Problem solution should require cross-discipline cooperation and expose students to situations where knowledge cannot be pigeonholed into tightly defined compartments.
- The problems should be set as far as possible in a real industrial context where there is a framework of competing financial, physical and personnel demands at both the business and the team levels, and should require students to develop and apply their existing knowledge to produce a prioritized range of alternative solutions.
- The problems should be real-life, practical, novel and unstructured in that there is no definitive solution or solution heuristic. (In addition, in the MDIP, students operate within an expectation that the sponsoring companies will develop any new products and recommendations for action designed by the students. It is worth noting that twenty-nine projects have been completed over the last five years and several companies have reported that they have acted on recommendations in reports prepared by MDIP Students.) According to Marton and Saljo [23, 24], such an experience should develop real understanding rather than short-term recall of isolated facts—deep as opposed to surface learning—and develop real professional behaviors, attitudes and values.
- The learning environment should provide students with an experience closely approximating real-life in a professional setting. Students should therefore be responsible for managing the team processes needed to produce an integrated solution to the problems supplied by industry partners. For example, students are responsible for identifying project priorities, for allocating tasks within their groups, and for timetabling the activities necessary to provide a solution to their problem, and ultimately preparing a report for the sponsoring company.
- The learning environment should foster the development of independence, written and oral communication skills, the capacity for inquiry and research, critical thought and analysis, and the effective use of information technology.

Organization of the subject—putting the theory into practice

The MDIP is designed for students at the latter stages of their undergraduate courses. Students at this level have attained some basic technical knowledge in their discipline, and have work habits that are sufficiently reliable and robust to enable them to benefit from participation in a relatively unstructured problem-solving approach that incorporates the features just outlined. The expected outcomes/objectives for each individual student from the program are as follows. During participation in the MDIP students should be able to:

- Formulate, through group interactions, solutions to business problems which require the integration of design, manufacture, marketing and financial accountability.
- Separate engineering, accounting, marketing and design elements into solvable elements; explore solutions mindful of the influence each discipline area has on the other.
- Demonstrate understanding of manufacturing design and the possible need for redesign.
- Exhibit committee chairperson, secretarial and reporting skills.
- Negotiate responsibilities within a group to ensure effective project management.
- Organize communication systems to ensure effective project management.
- Compile, present and defend a syndicate report on the project.
- Assess personal and peer performance in achieving objectives.
- Value the complexity of issues and range of people affected by the introduction of new products and technology.
- Appreciate the degree of involvement necessary in the decision-making process in a typical industrial situation.
- Demonstrate an appreciation of the need for business to produce a profit through a professional approach to the presented problem which respects the time of others, presents clear and well researched and analyzed alternatives, presents solutions which are mindful of the financial viability of the company and are ethical in terms of meeting all obligations to legal, health, safety, environmental, workplace relations and customer service considerations.

These objectives have a strong emphasis on process, life-long learning and communication skills, and little emphasis on the acquisition or development of understanding about a specific body of cognitive knowledge. However, the application and expansion of existing disciplinary knowledge to the specific problem is central to the project's success. It is clear that these high-order cognitive and affective behaviors require a different approach to assessment than the typical academic knowledge-centered assessment regime. This is where the authentic assessment strategies described later fit in.

An information session is held prior to the commencement of semester to familiarize students with the aims of the subject and to aid in the recruitment of marketing, accounting and industrial design students who take the subject as an elective. This session also provides some information to help achieve a balance of gender, nationality, discipline base and ability when students are assigned to their teams.

In the first formal class meetings students meet managers from the sponsoring companies who provide the problem brief, introduce the company perspective of the problem and discuss confidentiality, safety issues and communication with the company. Students also meet as a team for the first time and engage in icebreaker and other team building exercises.

The group size of eight to ten students makes a formal committee meeting structure essential, and enables each student to chair a team meeting once in the semester. In week two students are given some instruction about meeting procedure, draw up schedules for chairperson and minute secretary roles, elect a team manager, exchange contact details and organize their e-mail communication system, and visit their sponsoring company's factory for an orientation tour.

Week three sees students commence the problem-solving task. Problem solving strategies are discussed and students are encouraged to analyze their particular problem in a way that divides it into segments or a range of achievable tasks that fully exploits the diversity of the team. A strong emphasis is placed on the use of the committee structure and a formal meeting procedure, and the use of common project management tools to ensure that separate responsibilities and accountabilities are clearly established and monitored for each student.

An important feature of the MDIP is the approach employed to help students learn about diversity. Psychologists from the university's counseling service have assisted in the development and delivery of a series of five seminars organized around the themes of leadership and working in a team. Students learn about:

- dealing with differences in personality, learning styles, gender, discipline base and cultural background;
- understanding the challenges of diversity;
- developing the skills required to deal with conflict and motivation in heterogeneous teams.

As an aside, Asian students have reported that the MDIP is the only subject in their experience at the university that has enabled them to interact effectively with Australian students.

At Week 5 the team is required to produce an interim report of their work in progress. They are expected to provide both individual and corporate assessment of the problem, possible solutions and the lines of investigation they are planning to take. Also at Week 5 the students undertake the first of three peer assessment exercises in which they rate each other and themselves on four criteria related to their performance as team members.

Again in week 10 the team is required to produce a second interim report on their progress toward a solution to their problem. This report is expected to detail the lines of investigation followed, outline the information they have gathered that is relevant to the range of possible solutions considered, give some indication of a preferred option, and what work is still needed to complete the task in readiness for the presentation of the final report. A second administration of the peer assessment

exercise also occurs at Week 10. The first two peer assessment exercises are intended to be familiarization with the concept of peer assessment and to provide formative data for feedback purposes to each individual as a motivation toward improving their performance (should it be necessary).

The final report and the final summative administration of the peer assessment exercise are scheduled at the time of the live presentation to the management of the sponsoring companies in about Week 15.

Students are encouraged to keep a journal relating to the experiences they have encountered during the course of the project and their personal reflections and reactions to them. The purpose of the journal is to provide a database for the preparation of their written reflective report at the end of the project. These reports form part of the continuous improvement program associated with the MDIP.

The key features of the MDIP

- Students apply prior discipline-specific learning to real-life business problems and have the opportunity to learn from working managers in the participating companies. The problems require approaches based as much on interpersonal communication as analytical processes.
- Students learn to deal with ambiguity and uncertainty because problems are loosely structured and relevant information must be discovered, and sometimes, is not readily available.
- The learning environment is student-centered. Teaching staff act in a facilitative rather than a didactic leadership role to foster independence, cooperation, student ownership, creativity and the use of skills that promote life-long learning.
- The learning environment is team-based to facilitate cooperative learning, the development of interpersonal skills, and assists in learning to deal with diversity.
- A formal meeting structure is used to ensure that responsibilities and accountabilities are clearly established and monitored, monitor and direct progress on the problem solution, and to facilitate development of oral and written communication and interpersonal communication skills.
- A series of targeted seminars/workshops and the formal meeting structure help students develop interpersonal skills in leadership, negotiation and conflict resolution.
- Teams are multi-disciplinary to mirror the workplace—students learn the vocabulary and mindset of other professions and to improve their communication skills and the breadth of their understanding of business problems.
- Students participate in processes of peer and self-assessment and reflective practice.
- A formal continuous improvement program ensures the ongoing success of project outcomes.
- Oral and written communication skills are developed when students prepare and present final oral and written reports to the management of their company sponsor.
- Students' capacity for inquiry, research, critical thought and analysis are all fostered by product development work which requires them to spend a large proportion of their time investigating new products and markets and novel applications of industrial processes.
- Finally the use of information technology is addressed by students' use of e-mail and the Internet for communication and research, their use of Computer Aided Design (CAD) software, and the employment of modern display technologies in the live presentation of their report.

This combination of features in concert with the authentic assessment strategy outlined below represents a significant advance in the learning experience for the students in the program.

THE AUTHENTIC ASSESSMENT REGIME FOR THE MDIP

The formative element

Formative elements are an important component of an authentic assessment strategy [25]. Because the student-centered and student-managed multidisciplinary team format is new to students, formative evaluation and feedback is built into the MDIP program in several ways to support them in becoming familiar with the process and their roles in it.

At Weeks 5 and 10 when students submit their interim reports supervisors give detailed and rapid feedback on their progress. In Weeks 6 and 11 they receive feedback on their peer assessment, and during or after each weekly meeting feedback is given on individual performance as chairperson and minute secretary and through informal discussion about entries in personal journals. The two mid-semester peer assessments provide students with insight into the way the rest of the group perceives their performance and also allows them to become familiar with the process and interpretation of the results of peer assessment. If students feel discriminated against in the peer assessment, they can discuss the issues raised with their group supervisor, with a psychology master's student (from the area of Organizational Behavior) working in the MDIP as part of their own research and at the same time providing an independent source of data for the continuous improvement program, or with members of the university counseling service who assisted with the introductory team skills and leadership seminars.

The summative assessment element

As noted by Fredericksen [26] the value of a program (like the MDIP) with an extensive range of learning objectives in the development of real-life work-related and life-long learning

skills, depends on the criteria chosen for the evaluation process. Clearly such a program, employing an integrated/contextual-learning environment, requires a carefully managed authentic assessment regime that might include some or all of the following assessment approaches:

- performance assessment;
- criterion referenced assessment;
- systematic observations;
- portfolios and process-folios;
- journals [27].

Readers will note from remarks made above that the MDIP in fact makes use of all of these approaches.

Ryans and Fredericksen [28] warned that a common pitfall in the evaluation of performance is to assume that knowledge of relevant facts and principles somehow equates to an ability to perform a task. Others have noted that the evaluation of students' achievement of complex behaviors, like those expected of students in the MDIP, is prone to all the usual problems of measurement—sampling, reliability, validity, relevance, authenticity, and bias. Rudner [29], for example, also includes the notions of corruptibility, the appropriateness of using tests as motivators and various equity issues. Miles [30], based on the work of Linn, Baker and Dunbar [31] suggests a range of criteria that might be used to validate authentic (performance) evaluations. These include: consequences of assessment processes on teaching and learning practice, fairness, transfer and generalizability, cognitive complexity, content quality and coverage, meaningfulness, and cost and efficiency. As the MDIP team has discovered, it is necessary to be able to defend a non-traditional assessment regime on all of these criteria at some time or another in the life of a project.

The MDIP team adopted a rigorous criterion referenced approach to the evaluation of student performance on the eleven stated expected learning outcomes. Students are given written guidelines on the criteria that are used to assess each of the components that make up the final assessment. The overall assessment strategy is outlined in Table 1.

EXPLANATION OF THE ASSESSMENT STRATEGY

To produce an assessment of individual student performance that sensibly and fairly discriminates the performance of each individual within the overall group performance, the MDIP team agreed that an individual student grade would be made up by assigning 50% of the marks to the team performance, 50% of the marks would be allocated for performance on individual tasks, and that a process of peer assessment would be used to produce a measure of each individual's contribution to the team performance.

To address the issue of balance between product and process a set of assessment guidelines is issued to representatives from participating companies asking them to evaluate evidence of the process that produced the set of recommendations to their company as well as to their substantive content and feasibility. The three main products of the semester's work are the final written report, the live presentation and the reflective report. The process components are made up of the way the group works together and the performance of individuals as chairperson and secretary to the group.

Peer assessment

A frequent criticism of the assessment of group projects is that there is a tendency by faculty to give all students in the group the same mark regardless of the individual contributions made to the group effort. Too often non-contributing students are rewarded and the real contributors tend to be penalized. The use made of peer assessment in the MDIP largely overcomes this criticism.

The MDIP team was committed to the notion of peer assessment, not only because it is practiced widely in industry but also because they believe

Table 1. Overall structure of the assessment program indicating which objectives are assessed by each component.

Component of Assessment	Assessed by	%	1	2	3	4	5	6	7	8	9	10	11
Assessment of Group Performance (50% of total assessment)													
Final written report presented to company	Supervisor	15	×	×	×				×		×	×	×
	Company	15	×	×	×				×		×	×	×
Live presentation to company representatives	All supervisors	10	×	×	×				×		×	×	×
	Company	10	×	×	×				×		×	×	×
Assessment of individual performance (50% of total assessment)													
Reflective report	Supervisor	15					×			×	×	×	
Interim reports × 2	Supervisor	10	×	×	×		×		×			×	
Performance as chairperson	Supervisor	10				×							
Performance as secretary	Supervisor	5				×							
Group participation	Supervisor	10					×	×			×	×	×
Peer and self assessment	All team members							×		×		×	×

that this component is critical in discriminating the performance of individuals. Team members will know more about their colleagues and how they have performed within the group than either the supervisor or the industry representatives because they have been working with them closely for nearly fifteen weeks at times when the supervisor and the company cannot see them in action. Peer assessment is used as a means of discriminating each individual's performance within the group by multiplying the group score by an individual modifying factor. The modifying factor is a weighted sum of the scores obtained by each individual on four criteria: Reliability, Cooperation, Initiative and Citizenship.

Readers interested in a more detailed description of the peer assessment process, and the way the instrument was modified by feedback in the continuous improvement process over a number of years, are referred to a previous paper by Brown-Parker *et al.* [32].

Students are given detailed descriptions of the four criteria at each administration of the peer assessment instrument and are also given detailed guidelines on how to complete the peer assessment. In spite of its relevance, peer assessment is not without its critics for other reasons—students are not competent to make judgments about the performance of their peers; the process is open to cronyism and other forms of personal bias.

The MDIP has addressed these potential criticisms of peer assessment in two ways. Firstly, students are given a seminar on the importance of peer assessment in the workplace as a means of building and developing team performance, and how the process operates in practice. Secondly, the first two administrations of the instrument are used as training exercises and for formative evaluation. From their first contact with the MDIP students are aware that their assessments on the third administration of the peer assessment will have a significant effect on the final grade of their colleagues. They know that this is a serious commitment by the MDIP team and that it is done in the interests of fairness to reward individual contributions to the team effort. This use of peer assessment adds a new dimension to the assessment of a group report. In practice it has been found that the correlation between supervisor and student assessments of individuals is in the order of 0.7 to 0.8. The fact that the correlation is not around 0.95 or so confirms the value of having the extra perspective on individual student performance.

Company contributions to assessment

As mentioned earlier, to assist the participating company representatives in making an assessment of the written report and the oral presentations they are given a document that outlines the objectives of the program and some guidelines about the things one would expect to see in the report or to occur in the team presentation. It is also suggested that the company evaluate the report on any criteria that are important to the company. For example, does the report adequately address the assigned problem, does it address expressed company expectations, has adequate consideration been given to the exploration of possible alternative solutions, and are recommendations supported by concrete evidence. The value of the assessment by the industry partners is that students experience the consequences of a commercial assessment of the work they perform in a real situation. All supervisors attend all presentations and use the same guidelines as the company representatives to grade the presentations. At the final examiners' meeting a moderation process is worked through to compare all ratings of the reports and the presentations. On the rare occasion when a serious discrepancy is observed between a company and the supervisor ratings an adjustment to the grading is made at this time.

For the most part the companies have been impressed by the way students have tackled the problems presented to them and have indicated that recommendations will *be* acted upon. Any shortcomings in the reports are noted and included in guidelines to the next cohort of students as things to be aware of in writing their reports.

Committee skills

In the first meeting students are given a handout indicating the expected performance criteria in their roles as chairperson and minute secretary. Also the supervisor models these behaviors in the first two meetings of the group. The program is arranged so that students take minutes one week, produce an agenda (in consultation with the supervisor) and chair the meeting in the following week. Supervisors use a checklist of the expected behaviors to assess performance on the task.

Student performance as a team member is discussed in early team meetings and the criteria for assessment of their performance explained. The criteria used relate to the nature and quality of their contributions to the group meetings, whether or not they have performed allocated tasks, the way they relate to and treat other members of the group, attendance and punctuality of the meetings, how they listen and respond to the suggestions of others. The supervisor is present at all of the formal team meetings. Normally these meetings run for about one hour. It is recognized that a lot of work is achieved outside of the formal meetings and that significant interactions occur outside of this formal setting, which is why the peer assessment component is regarded as so important in the overall strategy.

Interim reports

Student performance in the preparation of interim reports is based on the submission of written material prepared by the individual students for inclusion in the group report. It is a way of assessing how diligently students have

performed assigned tasks from within the group. What it does not do is account for the joint efforts in producing the coherent document representing the total group effort. Again this is where the peer assessment component comes into play.

Journal and reflective reports

Finally students are counseled to maintain a journal/diary of their experiences and their reactions to them during the course of the project. At the end of the project they are asked to respond to a questionnaire about various aspects of the course and then to write specific comments about significant aspects of the program. Students are given a handout indicating the type of thing they might include in their journal, and are also given model responses to reflections about issues. Again the emphasis is requiring students to provide evidence that supports any comments or recommendations and to steer them away from mere speculation and opinion. Journals/diaries are checked and discussed in a random/informal fashion at the regular team meetings.

The reflective reports have dual goals: to encourage students to reflect on their learning and the group's processes, and also to provide feedback to the project team as part of the continuous improvement process. The recognition that each group of students benefit from their predecessors' feedback and that their comments will benefit their successors, appears to add further motivation for a serious approach by many students.

THE MDIP RESPONSE TO POTENTIAL CRITICISMS

As stated above, innovative learning programs and assessment schedules often provoke criticisms from traditionalists, who mainly criticize two issues:

- the faculty resource implications;
- the validity, reliability etc of the assessment.

Both of these are discussed below.

Resource implications

The Monash MDIP has found from extensive student feedback that 8 or 10 students is the preferred group size. While this is a generous staff-to-student ratio it does allow each student scope to contribute effectively in all group activities and also allows the problem to be divided into an appropriate number of areas of responsibility. It could be argued that having a faculty member devote one hour each week to observing a meeting of 8 or 10 students is inefficient. However, there are no lecture notes to prepare, and only two interim reports to mark from the whole group. End of semester marking involves devoting one day to listening to student presentations and reading and assessing a detailed report of up to 50 or 60 pages. However, in comparison to the preparation of lectures and tutorials each week in a traditional program, the marking of regular tutorial exercises and papers and the setting and marking of exams for the same number of students, MDIP staff report comparable amounts of time are involved. The real bonus is that the facilitation and assessment roles in the MDIP are reported by faculty to be more rewarding than reading repetitive papers on the same subject. The regular staff-student contact in meetings can also lead to positive relationships that are satisfying to both groups.

While there is a time commitment to arranging client companies and preparing the few introductory seminars, there is less time commitment by the subject coordinator in aggregating test, tutorial and exam marks. The time that is spent in establishing projects is also an opportunity to network with industry (a particularly appropriate activity for industrial engineers). The project has also allowed faculty to use the projects as a means of maintaining contacts with alumni and has formed the basis for a number of research papers.

Criticisms of the assessment strategy

As indicated previously, student assessment strategies are often challenged on the basis of sampling, validity, reliability, relevance, bias, corruptibility, motivation and equity. Each of these is briefly considered below.

- *Sampling, reliability and validity* are real concerns in the conduct of exams and often, elaborate management and statistical procedures are employed to demonstrate that the issues have been adequately addressed. They are also issues in the authentic assessment of a group project. In the MDIP reliability is addressed by using multiple approaches and several inputs to assess performance on objectives (see Table 2).
- *Validity* is partly addressed by having the client company assess the value of the project report to the company operations. The validity of the course is addressed because each year it is subject to the scrutiny of course coordinators in the different disciplines and must satisfy them that the program meets faculty objectives.
- *Sampling* is addressed in the MDIP by the observation of all formal meetings using a checklist of desired behaviours and outcomes. All written material produced by each team member addressing his or her area of responsibility is assessed and journals are subject to random scrutiny.
- While the *relative weighting* of group and individual assessment could be challenged, it is obvious that if a group outcome is required, then the group performance must be assessed. The real issue here is that some students are not able to get a 'free ride' on the efforts of their colleagues. The peer assessment, the systematic faculty observation and the reflective report ensure the efficacy of the 'process'.
- While individuals may gain help from other

team members that improves their grade, this is an inevitable aspect of *teamwork* and reflects what happens in real life. This has been balanced by the detailed observation of *individual performance* by the supervisor and by using peer assessment

- While *victimization and cronyism* are potential problems with peer assessment, the formative feedback from two practice administrations keeps this to a minimum. Written guidelines and the availability of counseling also balance these potentially negative influences.
- Issues of *corruptibility, bias and equity*, all relate to the fairness of the assessment. Reflective reports have indicated some ambivalence about the process of peer assessment but there is general agreement that it produces a fair result. However, such criticisms have been fewer of late because of changes made to peer assessment. These have included: reducing number of questions on the instrument; better explanations of the peer assessment process, making the feedback simpler and providing a number of outside sources of support to discuss results. In addition, the faculty facilitator, client company and peer assessments are all submitted to a moderation process which is achieved by having all supervising faculty attend and assess each of the end of semester presentations and double marking the final written reports. More than one member of staff also vets the students' reflective reports. Students with a non-English-speaking background are sometimes reluctant to contribute verbally in meetings, leading to a potential reduced mark. These difficulties have been addressed by encouraging such students to present much of their weekly feedback in written form and by providing guidelines to chairpersons that suggest techniques to ensure that all students have time and opportunity to contribute.
- *Student motivation* can be an issue if course goals and assessment strategies have different emphases. Questionnaire responses indicate that, with the exception of earlier forms of peer assessment, the students see all aspects of assessment as relevant to the project and the goals of the subject, and they rate the assessment the fairest they have experienced.

CONCLUDING COMMENTS

Governments and employers have made strong criticisms about the shortcomings of graduates produced by university courses in engineering and business. This paper has outlined some of the processes employed by a group of faculty at Monash University in developing the MDIP in a deliberate attempt to address these shortcomings.

The MDIP is set in an integrated/contextual-learning environment where students are challenged to engage in real-world problem solving and to develop life-long learning skills. The students work in multidisciplinary teams on unique real-world problems with realistic and achievable outcomes. The learning environment is further enhanced by a comprehensive authentic assessment strategy. The course goals require an assessment program that is about observing and evaluating behavior in a realistic professional situation. It is criterion referenced, contains a wide range of feedback opportunities and discussion about performance, uses a variety of appropriate assessment tools, and obtains data from several sources as appropriate. A continuous improvement process is employed to monitor quality of the MDIP program. Feedback is obtained from all stakeholders in each offering of the program, and, through regular contact with former students after they enter the workforce. This process has resulted in some adjustments to the program. Generally the MDIP has enjoyed a positive evaluation from industry partners, students (both during their course and after entering the workforce) and academic peers.

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APPENDIX

The development of the MDIP from previous group-based programs at Monash University

The MDIP and its attendant authentic assessment regime has its roots in a number of large-group projects that have been implemented over the last 20 years at Monash University Caulfield campus (formerly Chisholm Institute of Technology until 1990), in an attempt to address two major educational concerns. The first was a general low standard of performance in final year mechanical engineering projects and the second was concern with students' inability to transfer knowledge from one subject to another.

Traditionally, final year students had been required to complete a project over both semesters of the final year of their degree. The obvious object of such projects was to apply the knowledge from relevant subjects in their course to a particular problem. While the best of these projects were excellent, many were considered to be at best mediocre. Anecdotal evidence indicated that students saw the project as uninteresting and just another subject rather than a great learning opportunity that would in turn be capable of impressing prospective employers. The second issue based on staff observation showed that knowledge gained in 'materials' subjects was not applied effectively in selecting materials in 'design' classes. To address both of these issues, it was decided to develop a more motivating and integrated approach to final year projects, in which students would require to integrate their knowledge, both from a number of subjects and with a number of colleagues working on different aspects of group projects.

The Mileage Marathon project

The development of an entry for a fuel efficiency competition, the Mileage Marathon, was chosen as an appropriate focus. The vehicle needed to be designed, constructed, tested and optimize all aspects of any engineering development process. Approximately 20 students undertook different aspects, such as body design and construction, aerodynamics, transmission design, structural analysis, engine design for minimizing fuel consumption, etc. Wellington [A1] indicated that the students involved in this large

group project not only were highly motivated, but also were required to draw on all aspects of their course to achieve a suitable level of performance. Four entries were developed over the next 7 years, with a best performance of 2854 mpg (imperial). It was also found from questionnaires, that students who were part of this project showed significantly greater ability to work with staff (supervisors and technicians), better ability to integrate knowledge from different subjects and better communication skills than their peers.

Solar vehicle development projects

The development of solar powered vehicles for the '87, '90 and '93 World Solar Challenges (WSC) allowed the same objectives to be addressed but also enabled a significant advance in interdisciplinary partnerships to be established. This 3000 km race from Darwin in the north to Adelaide in the south of Australia, provided an excellent opportunity for relevant disciplines to apply their specific knowledge to issues of environmentally friendly transport in a challenging and motivating manner. It needed the design, construction and testing skills of mechanical and electrical engineers and the project management and logistics skills of industrial engineers. Wellington [A2] discussed the first Chisholm solar vehicle development for the 1987 WSC which involved an initial group of about 20 mechanical, 12 electrical, 6 industrial engineering students. Students accepted specific responsibilities on which they had to report to the whole group at fortnightly meetings. These meetings ensured not only that all components developed were compatible with each other, but also enabled the students to gain insight into organization and integration of the project, working within a restricted budget and ensured that they developed effective communications skills to present and defend their ideas.

In 1989/90 a more professional approach was adopted by establishing a more multidisciplinary project with engineering students being joined by marketing students who took responsibility for sponsorship, promotion and ultimately race team management. Graphic design students developed a team logo, industrial design helped with concept drawings and ergonomic issues and psychology students researched stress responses among race team participants. The then Casey College of Technical and Further Education was made a member of the consortium, providing key skills in composite manufacture and catering. Burke [A3] (private communication) a mature marketing student who took responsibility for promotion and ultimately race team management, stated that her management skills were enhanced as she 'went into the project thinking, How do you make these engineers think like marketers? Then I realized over time that it was going to be more productive for the marketer to think like an engineer. This was the key learning for me, and probably the most insightful of my business career.'

Wellington [A4] surveyed electrical engineering students who had played major roles in the three WSC projects. There was overwhelming agreement that the project had:

- increased their understanding of the complexities of real problems;
- come to appreciate the importance of testing in a realistic environment;
- learnt significant new discipline based concepts;
- developed insight into aspects of other disciplines, e.g. manufacturing, management, finance, publicity, group dynamics and the benefit that came from seeing the performance of the whole vehicle.

Other issues on which agreement about what was learned was less strong included:

- application of theoretical knowledge to a practical problem;
- integration of knowledge from a range of subjects;
- team work skills;
- influence of the environment.

Assessment of vehicle projects

All of the above projects involved substantial groups of students, commonly 10 to 50 in any one year. Each student was enrolled in their 3rd or 4th year 'project' subject for which they needed to be assessed. Traditional projects carried out individually or in pairs, have long been assessed on a range of criteria with the supervisor and subject coordinator placing great weight on final presentations and reports, in addition to the degree of success the project achieved in meeting its goals. The much larger group projects appeared to set a more challenging assessment issue, but due to frequent meetings at which students reported and defended their specific project, the requirement to produce a subsystem which had to integrate with all other parts of the vehicle and do it on time, the real student competence was being assessed continuously rather than just their ability to produce a good presentation and report. When students produce design drawings for typical design subjects, they are assessed and receive feedback based on the thoroughness that the marker is prepared to give. In the large-scale projects, they also received feedback from peers working on related projects, other supervisors and, most testing of all, the technical staff who *had* to make or help make the actual component. The final evaluation occurred when the vehicle as a whole was tested and poorly designed subsystems needed modification. The ability to then compare that vehicle with its competitors, including the best in the world from other universities and manufacturers including General Motors and Honda provided a further level of learning unavailable in many other situations.

The transition from vehicle projects to industry projects

While the 13 years of vehicle development projects had enabled many generations of students to develop a broad range of skills, it was decided that a similar philosophy be applied to the Monash Industrial Engineering program. As industrial engineering students have a greater focus on process design rather than product design, it was decided to establish large group projects for students to work in industry as consultants. In 1995, a pilot study was set up with groups of approximately 10 industrial engineering students carrying out an evaluation of alternative printing processes for a plastic processing company. It was apparent that many of the vehicle objectives and assessment strategies could be adopted, but with the greater emphasis in industrial engineering on organizational skills, chairing and minuting of meetings which were also assessed by the supervisor acting as observer.

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