

DEVELOPING EFFECTIVE TEAM PLAYERS WITH GOOD INTERPERSONAL SKILLS

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INTRODUCTION

In education, when a wide range of topics – such as stress analysis, systems engineering, and finance – are taught and assessed separately, the result is often that the information gained by students is retained separately and rarely considered together. However, businesses need staff who can draw on different topics and use them together as necessary in order to successfully cope with particular situations. Businesses also require employees able to work together – sharing, supporting, co-ordinating, communicating – in order to achieve the best results in the shortest time and in the most cost-effective way.

Group projects were introduced on technical MSc programmes more than 25 years ago, in response to the demands of business. Over the years the shape of the project has evolved to reflect both the changing demands of business and lessons learned from running the project. Today, there are two main aims of the project: to give students the opportunity to apply their technical learning to real, live problems in organisations; to support the development of students' interpersonal and team working skills (soft skills). All projects are industrially-sponsored and worth 20% of the degree.

Industry needs people with good soft skills, and this paper focuses on the development of soft skills during group projects. It outlines a project and how it is run, the work done to prepare the students for a project, and feedback mechanisms. It concludes with the benefits to the students and their prospective employers.

THE PROJECT

Group project

Overview. This is a major project undertaken with an external organisation. It is a requirement that the project is important to the organization, and that appropriate resources – such as relevant data and staff time – are readily available. Recent projects include designing and building a new high-volume production machine, analysing and simulating a manufacturing operation, and investigating ways to improve knowledge management. Project sponsors include large international organisations like Ford, Airbus, and Rolls-Royce, as well as smaller and local organisations such as a Primary Care Trust and a local manufacturer of double glazing.

The duration of a project is 3 months, and each student is expected to put in around 400 hours of work. Each project is demanding, and gives students the opportunity to transform their basic learning about soft skills through the full range of competences described by Bloom(1): knowledge, comprehension, application, analysis, synthesis, and evaluation.

Structure. Each project has two phases. In Phase 1, students investigate the problem, carry out an analysis, prepare their recommendations (usually to develop or implement specific plans, but occasionally to carry out further research), present them to the client, and agree the actions and deliverables for the next phase. In Phase 2, students work to produce the deliverables agreed with the client. At the end of both phases the client receives a written report and a formal presentation; the reports are written with businesses in mind – they comprise an executive summary, a concise text (maximum of 15 pages), and appendices.

Size of group. It has been found that with groups of less than 10 people, few 'team working problems' tend to emerge. Problems

are seen as valuable learning opportunities and they can provide students with the opportunity to discuss, amongst a generally supportive group, ways to resolve them. It has also been found that in groups with more than 15 students it is possible for some students to 'hide'. The preferred group size is in the range of 10-15.

Management of a project. After an initial brief by faculty and the client, the students take ownership of the project and become responsible for all activities, including setting and reaching objectives, and liaising with the clients. A new leader and deputy leader are appointed each week, with the deputy leader moving into the role of leader; all students should hold both of these roles at least once during the project.

A formal review meeting, with minutes and an agenda, is held weekly. At this meeting all students provide an update on their work, progress against the project plan is monitored, and planned activities for the coming week are discussed. The chairperson at this meeting is the leader, and they are required to produce an agenda at least 24 hours before the meeting; the secretary is the deputy leader, and they are required to distribute minutes within 24 hours of the meeting. Faculty attend these review meetings, and a copy of the minutes is sent to the client.

The role of faculty is to provide guidance, support and questioning throughout the project; they only direct when they consider it essential. Students are encouraged to work within their group to resolve any conflicts; if faculty become involved in conflict issues, they try to adopt the role of facilitator rather than arbiter.

Clients provide a lot of support to the students and stay in close contact with them. Like faculty, clients invariably only direct when they consider it essential.

Activities. The range of activities undertaken is dependent upon the project, but all projects involve some liaison with the client, data gathering, analysis, development of recommendations, production of reports and presentations.

Students are responsible for planning and managing the all aspects of the project. This includes administrative tasks such as booking transport, accommodation, and rooms for meetings, as well as making all arrangements for the final presentation.

Close liaison with the client is very important, and a Liaison Officer is appointed to this task for the duration of the project. There may be many visits to the client's organisation, and other companies too.

Sub-groups are often set up to be responsible for specific project tasks. As the focus of the project changes, e.g. from data gathering to analysis, the need for sub-groups may change. Sub-groups may, therefore, be regularly created and disbanded to reflect the changing needs of the project and the skills of the team members.

PREPARATION FOR THE PROJECT

Introduction to team working

In preparing students to create and sustain successful teams, two areas are explored: the needs that teams have, and the roles needed within a team. While much of this material is taught in classroom sessions, use is made wherever possible of videos, role-plays, and group exercises and discussions.

Needs of a team. Adair(2) identified the needs of a team, and the associated leadership roles. He identified three different needs: individual needs, group needs, and task needs. Individuals' needs include motivation, training and development, and personal recognition; group needs include motivation, team spirit, and communication; task needs include setting objectives, planning, task and resource allocation, and monitoring and control.

Adair recognised that leaders exist at all levels of an organisation, from the chairperson of a large company in charge of thousands to a team leader in charge of 2-3 other people. Irrespective of the level of the leader, if a team is to be successful then the three needs – of the individual, group, and task – all have to be met. In group projects, leadership has

therefore to be displayed not only at group level, but also at sub-group level.

Team roles. When Belbin(3) originally looked at teams, his view was that the brighter the team members the more successful the team would be. His research quickly disproved this theory, and through his work he identified nine different roles that come into play in team working. Although individuals may, at times, adopt many or all of these roles, most individuals are stronger and perform more effectively in some than in others; some individuals are extremely strong in only a few roles, while others are strong over a larger number.

The roles he identified were:

the co-ordinator - the social leader of the group, who clarifies the group objectives and set its agenda;

the shaper - the task leader of the group, who gives shape to the application of the team effort, trying to unite ideas and produce patterns;

the plant - the ideas person of the group, the most imaginative and usually the most intelligent;

the implementer - the practical organiser of the group, turning the ideas of the plant and the shaper into manageable tasks;

the resource investigator - the “Fix-it person” of the group, always aware of a resource (person or information) that can help in the situation;

the monitor/evaluator - the analyst of the group, the person who is best at assimilating, interpreting, and evaluating large volumes of data;

the team worker - the mediator within the group, sensitive to atmosphere and very aware of individual needs and worries;

the completer-finisher - the progress chaser of the group;

the specialist - someone who supplies knowledge and skills in rare supply and who prefers to contribute on that limited front.

In a successful team most, if not all of Belbin’s roles, are needed. For a given project, the importance of the different roles will vary according to the task and stage of the project: a research project may have a much higher requirement for *plants* than *shapers*; the need for the *co-ordinator* is likely to be higher at the start of a project, while the need for the *completer finisher* may be greater towards the end of a project.

Introduction to interpersonal skills

A number of topics are covered, and the key ones are presented below. This work is based initially around classroom sessions, but extensive use is made of a wide range of short individual and small-group exercises, videos, and role-plays.

Meeting management. The role of the Chair and Secretary are described, and ways of managing a meeting are discussed. Techniques such as how to add value in discussions, e.g. by not repeating or going off on tangents, are explored.

Communications. Students have lectures on written and verbal communications throughout their MSc programmes. They have many opportunities to deliver formal and informal presentations, and at least one presentation is recorded on video; they also have to produce a number of reports and written assignments. Feedback is given on these activities.

Listening. This is a fundamental part of communications. When students are asked what skills they would like to develop in themselves and what skills they think their peers need to develop, almost all report that their peers need to improve their listening skills but few list it as a need for themselves. Some of the ideas of Bolton (4), such as attending, following, and reflecting, are explored.

Reflective practice. The learning model developed by Kolb(5) – experience, reflect, formulate ideas, experiment - is introduced. Students are encouraged to reflect regularly on their performance, seeking feedback from peers and faculty as appropriate.

Assessing others and giving feedback. This is a demanding task, and one that all too often in business is done badly. Ways to identify what should be assessed, how to assess objectively, and how to give feedback (good and bad) in a constructive and supportive way, are all explored.

Making use of Belbin profiles

Individual Belbin profiles. All students complete an on-line Belbin questionnaire that identifies their preferred roles at the time of completing the questionnaire. While some students identify completely with the preferred roles generated from their questionnaire, others do not. However, after students have shared their results in small groups - and everyone has heard how they are seen by others - the preferred roles are invariably accepted by all students.

Students are given an assignment that requires them to reflect on their behaviour and compare that with their preferred roles. It is very important that they are aware of the types or activities that they are most comfortable with and competent at performing.

Using Belbin profiles within the team. In general, students – and all of us – perform better in roles we enjoy and are best suited for. Students are encouraged to think about everyone's preferred profile when allocating tasks within a group project; all too frequently in business, people are put into inappropriate roles for their skills because of a lack of understanding of both their own skills and the skills needed in a particular task.

However, it is not always possible to allocate individuals to tasks for which they have an appropriate Belbin profile. One situation in the project is when appointing leaders and deputy leaders as all students are required to hold these roles. It is considered important that all students experience these roles, and become aware of the range of issues and difficulties that have to be addressed by these roles; it also enables students to experience roles that they may be less suited for, as well as those that do suit them well. This is an important difference between group projects and pure consultancy.

FEEDBACK ON PERFORMANCE

Students and faculty are encouraged to give each other feedback regularly and in an informal way whenever appropriate. Twice during the project, at the end of Phases 1 and 2, faculty formally give students feedback based on their own observations and inputs from other students.

When the feedback is given, ways of exploring and improving any weaknesses are explored in detail with students. At this point students are encouraged to develop their own action plans to help them become more effective.

In the past, students were only given formal feedback on their performance at the end of the project. Three years ago, additional feedback at the end of Phase 1 was introduced. Although this increased significantly the staff workload, students have commented very positively about the opportunity to learn about some of their weaknesses before the project is over; it gives them the opportunity to try doing things differently in a supportive environment.

Data for formal feedback

Faculty. After each weekly review meeting, faculty enter their observations on each student on a simple form. On this form, each student is graded under a number of headings, and comments are added as necessary.

Students. At the end of both Phase 1 and Phase 2, students are required to produce a written assessment of themselves and each other. For themselves, they are required to write their achievements and weaknesses. For their peers, they are required to consider the performance of each and:

- rank everyone (excluding themselves, and give everyone a different ranking) under a number of headings;
- identify two strengths and two areas of improvement for each of their peers (strengths have included: hard worker, quality work, always meets deadlines, fun to work with; areas for improvement have included – idle, arrogant, always late, does the minimum, does not listen);

- rate the overall contribution to the group of each.

This information is collated and an individual written summary, with all comments recorded anonymously, is prepared for each student.

Formal feedback sessions

Faculty meet with each student individually to review their performance at the end of both phases of the project. The normal procedure is to hear the student's own views, and then provide feedback from their peers and faculty. These meetings also give students the opportunity to give feedback to faculty.

Feedback to students. Where the feedback shows that several people have identified the same area for improvement, then that area is explored with the student. Sometimes it is found that the observations are incorrect, e.g. a quiet student may do a lot of valuable work but only one or two others are aware of it so they are perceived by the majority of the group as being idle. When the peer observations are correct but the student is in denial and has a highly inflated view of their performance, extra care and support has to be provided. At the end of the feedback session, improvement plans are developed with students – either to make others aware of the true picture, or to improve areas of weakness.

During feedback sessions at the end of Phase 1, students are encouraged to talk to their peers about the feedback they have received and about the plans they need to make to improve their performance. It has been found that students who have actively sought the support of others in Phase 2 tend to make greater improvements than those who do not.

Feedback from students. At the individual feedback sessions students are asked if they have any feedback for faculty – in particular, anything faculty could have done differently to improve the performance of the group or individuals. Normally there are no suggestions for change, and students are positive about the about faculty support and inputs.

Occasionally, at the interim session, students say they would have liked more specific project objectives; this tends to be when the original brief from the client was very open or loose. On such occasions, students are reminded that this is a very common situation at the start of 'real' projects, and they need to resolve the matter by talking within the group and with their client.

Sometimes students ask for faculty to become more involved when another student does not pull their weight. These students are reminded that the group needs to address these issues, and ways to do this are explored with the students; if the matter cannot be resolved by the students and the matter is raised formally, faculty do become involved, but only in a facilitating role.

CONCLUSION

The group project gives students an opportunity to develop their team working and interpersonal skills, as well as applying technical learning to a real situation. Comparison of performance evaluations carried out at the end of Phase 1 and Phase 2 by both students and faculty has shown that most students improve their soft skills significantly during the project.

Feedback from students has confirmed the view of faculty that the introduction of feedback part-way through the project has been very effective in helping students to improve their soft skills. It also gives faculty the opportunity to encourage students individually to be reflective and apply Kolb's learning cycle; this is a skill that should be useful to them throughout their working lives.

The programme to develop students' soft skills is continually evolving, based on feedback from students and research in the field. One change being explored is to have all students participate in formal, open feedback sessions.

Students and faculty all consider the group projects play an important role in developing their soft skills. With enhanced soft skills, the students are able to contribute much more effectively when they join organisations.

Clients benefit too from these projects. They have a 10-15 strong, high-calibre team supported by faculty, working on a significant problem for 3 months.

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ENHANCING CRITICAL THINKING SKILLS IN FIRST YEAR ENGINEERING STUDENTS

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ABSTRACT

Students come to first year engineering degree courses with a variety of learning styles and experiences. Many students can solve problems but lack the ability to critically analyse data and results, and are unable to present the data in meaningful ways. There can be an expectation that these generic attributes are either already present, or will be developed by osmosis through the degree program. This paper describes how learning outcomes are achieved, generic student attribute skills are fostered and experimental reporting skills are nurtured in a specialised unit in experimental methods.

Students are introduced to programming, problem solving and analytical skills using software such as LabVIEW and MATLAB. These skills will then form a basis for later studies. The focus is on developing the 'tools' for problem solving early in the degree program, and giving generic skills a prime focus rather than allowing them to become a peripheral issue to the 'content' of the engineering degree.

Students are encouraged to explore the relationship between theoretical predictions and experimental results. In particular students are encouraged to critically appraise experimental data collected, apply error analysis, discuss and present results meaningfully and reach conclusions.

INTRODUCTION

The Department of Maritime Engineering at the Australian Maritime College provides four-year, full-time Bachelor of Engineering Degrees in:

- Naval Architecture,
- Ocean Engineering,
- Marine and Offshore Systems.

Student numbers vary between 70 and 85 in the first year engineering degree program.

The focus of this paper is on the content of the unit 'Experimental Methods' and its delivery to a multi-disciplined group of first year engineering students. A description is provided on how learning outcomes are achieved, generic student attribute skills are fostered and experimental reporting skills are nurtured.

UNIT PHILOSOPHY

Studies by Felder and Brent(1) confirm that students come to first year engineering degree courses with a variety of learning styles and experiences. Often students can solve problems but lack the ability to critically analyse data and results, and are unable to present the data in meaningful ways. Students can experience a significant contrast between school where they may rely more on being told how to do things and University where they are required to be independent learners who can work things out for themselves.

Sometimes at university there can be an expectation that these generic attributes are already present. Bertolina and Thompson(2) assert that in many current engineering courses, skills such as teamwork, critical analysis, leadership and lifelong learning have often been developed in an osmotic manner. We believe that it was important to do something beyond expecting engineering undergraduate students to improve as critical thinkers as an emergent property of their degree studies. Critical thinking requires the ability to make and defend conclusions based on evidence and we felt that this was best done within a defined context (in this case experimentation). There needs to be a clearly stated intent to develop critical thinkers. This can be more easily achieved if there is a

mapping of the 'skill' through the degree. For instance, the use of Excel might be introduced in a first year mechanics unit (as part of an assignment requirement) reinforced and extended in an electrical unit, and then becomes expected knowledge in later years, and required in units.

However, we were reluctant to develop a new unit where only critical thinking would be taught. Some courses in analysis or perhaps numerical methods take this approach, where the techniques can be separated from the content in the same way that a student might learn calculus, and only later apply it to mechanics or fluid mechanics after assimilating the knowledge. The problem with this method is that the students often fail to see the relevance of the skills they are learning (as has been the case with many mathematics and programming units in the past).

It is difficult to *teach* critical thinking. There must be willingness on the student part to engage the ideas. There is also a need for a setting for the ideas to be developed. Too trivial a problem will not be engaged; too difficult a problem will not allow the student to become involved at the right level. In Experimental Methods the unit has little explicit content beyond the methods, techniques, tools and ideas presented, there are a number of practical sessions, where real data is recorded, real measurement equipment is used and real safety standards must be met. While the cognitive content of these laboratories is not essential to the unit, it is important that the students engage real problems, rather than applying critical thinking to an artificial problem, or something they have seen many times before. The practical sessions are designed to introduce the students to new and diverse experimental situations such as a towing tank (used to physically model a ship's hydrodynamic behaviour), engines, fluid flow, and electrical equipment, in different laboratory environments. The sessions also have a variety of different measurement techniques and instruments – Venturi tubes, multimeter and oscilloscope, tachometer, mechanical loads, data acquisition using temperature sensors – to measure a diverse range of physical variables. The generic concepts in the unit can then be seen applied to the particular problem at hand. The students are encouraged

not merely to make the appropriate measurements, but to consider the factors affecting the measurements, how the values might be estimated, and how to check results as they go using 'back of the envelope' calculations.

Engineers Australia(3) list ten generic attributes considered desirable for graduate students to possess and at AMC these ten attributes have been mapped to individual units in our degree programs. The generic attributes addressed in Experimental Methods are as follows:

1. The ability to apply knowledge of basic engineering and science fundamentals;
2. The ability to communicate effectively;
3. The ability to understand problem identification, formulation and solution, and
4. The expectation of the need to undertake lifelong learning and capacity to do so.

In this unit we are seeking to equip students with a generic 'problem solving toolbox.' The toolbox can be considered to consist of real tools and conceptual tools.

Real tools are used to help students solve a problem. For instance a calculator helps students to solve problems, but they need to know how to use it first. Experimental Methods introduces students to new problem solving tools and shows them how they can be used to solve problems in general. Examples of real tools include:

- MATLAB, LabVIEW, Excel,
- Data analysis, error analysis, statistics,
- Sensors and transducers.

Conceptual tools provide students with new ways of thinking, and so allow the students to analyse totally new problems. Examples of conceptual tools include:

- Algorithms and flow charts, numerical techniques,
- Research skills, experimental design, report writing,
- Analysis techniques, and mathematical modelling.

Clearly there is a measure of overlap between the real and the conceptual tools.

The work described here is underpinned by the belief that critical thinking and lifelong learning can be fostered by providing a rich learning environment where students are encouraged to read, discuss and use the concepts in a variety of challenging projects.

IMPLEMENTATION

Experimental Methods is a 12.5% credit unit taught in first semester to first year students, with the following content:

- Computer Programming Skills (26 hours, 1 lecture and 1 tutorial per week, plus laboratory visits as required)
- Experimental Skills (26 hours, 1 lecture and 1 tutorial per week)

Each of the above dot points will be discussed more fully. Whilst separate topic headings have been identified for the delivery of this unit, it should be remembered that the acquiring, developing and assessing of individual skill sets is often integrated across the unit.

Computer Programming Skills

We do not seek to teach the students to be programmers, rather we are teaching them the rudiments of programming in the context of MATLAB and LabVIEW. There is less need for the modern engineer to be able to program in a language such as FORTRAN or C++. It is however important that they can use languages such as MATLAB and LabVIEW to solve problems, to manipulate and present data, and to simulate processes. The majority of the students had either never programmed at all, or had only encountered Java. Hence it is assumed that students have zero programming skills before the course begins.

Students are first introduced to LabVIEW over a six-week and then to MATLAB over a further six-week period. Both software packages use the format of one lecture and one tutorial per week.

Some generic programming skills are also introduced. Algorithm design is presented. Students are expected to generate 'solutions' to problems by producing a flowchart or algorithm

of the problem. It is intended in 2006 that students will bring their 'solution' to the tutorial session as a flowchart (for LabVIEW) or a pseudo-code algorithm (either is acceptable for MATLAB). Too often students think the computer will solve the problem for them, and start typing before thinking about the problem. The concept of solving a problem takes a new form when a computer is used. The same is true of experiment design, an experiment is designed to solve or investigate a problem, and it is the design of the experiment which is one part of the 'solution' and the mechanics of performing the experiment is analogous to 'implementing' the solution. This also maximises the amount that can be performed in a tutorial session, since implementing a solution and debugging is often a time consuming exercise for new programmers. After the first session introducing the software environment of LabVIEW and MATLAB, the next 5 sessions present the concepts of functions, loops and control structures, symbolic expressions, matrix representation and I/O, and numerical techniques in terms of real engineering problems.

Students are encouraged to think of LabVIEW not only in term of data acquisition or instrument control, but also for general purpose applications such as database development, data analysis programs and network communications.

Particular emphasis is placed on developing student's ability to approach computer programming in a logical manner. The need to create flow charts, develop algorithms before writing code is stressed. Importance is placed on developing good error checking techniques within the code, and for debugging purposes. The graphical nature of LabVIEW means that programming, using a flow chart as a basis, is a relatively easy concept for students to acquire. LabVIEW is an easier way to approach the harder concepts of loops and case statements.

Students undertake a major individual assignment using LabVIEW in which they are required to write a computer program for data analysis and presentation. Using data, they have acquired themselves in a laboratory session in the towing tank, students write a program to determine the full scale resistance characteristics of the test vessel.

The 6 weeks spent on MATLAB (one lecture and one tutorial session per week) introduces the possibilities of MATLAB, and encourages students to use the software as a generic problem solving tool. It is intended that students will be expected to use LabVIEW and MATLAB in future years of the degree program, and hence build on their skills acquired in year 1.

Experimental Skills

Students receive 13 formal lectures on basic experimentation theory, including:

- Occupational Health and Safety in Laboratories.
- Instrumentation and measurement.
- Error analysis and statistics.
- Data analysis and report writing.

Understanding and application of the theory is underpinned with weekly tutorial sessions and laboratory work. For example, students are introduced to error analysis concepts using Excel through a combination of lectures and tutorials.

In 2006 the tutorial problems will be completely linked to the real problems students have encountered in the laboratory sessions. So they will model fluid flow, perform a linear regression on their loaded beam data, plot the loading effects of electrical meters using user interface and loops.

Students should enter the second semester of their first year of studies with a toolbox of generic problem solving skills associated with relevant software.

Sepahpour(4) believes that Laboratory experimentation is a critical link for a thorough understanding of scientific and engineering theories. He states that development of the laboratory components plays a significant role in the enhancement and completeness of engineering courses. In Experimental Methods, students are also encouraged to develop research skills by recording information about the experiment, not merely the relevant raw data. Before they leave the session, a simple graph or evaluation is performed so that in a one hour session they have been introduced to

a laboratory environment, equipment and measurement devices, physical concepts, and generated a result. These results may then be further analysed in later tutorial sessions.

Laboratory work in a curriculum is very resource intensive but it provides significant benefits such as: the acquiring of skills in using real equipment; gaining an insight into phenomena of interest; developing measurement skills, obtaining an appreciation of experimental errors and an awareness of any simplifying assumptions that have been made. Laboratory exercises can also be used to develop in the student the skill of analysing experimental measurements and reaching relevant conclusions.

Feisel and Rosa(5) state that, 'When undergraduate students go to the laboratory, it is generally not to extract some data necessary for design, to evaluate a new device, or to discover a new addition to our knowledge of the world. Each of these functions involves determining something that no one else knows or at least that is not generally available. Students, on the other hand, go to an instructional laboratory to learn something that practicing engineers are assumed to already know. That something needs to be better defined through carefully designed learning objectives if the considerable effort devoted to laboratories is to produce a concomitant benefit.'

In this unit, students are required to submit a single formal laboratory report on one experiment. Only when students have completed all the experiments are they allocated an experiment to write up. Students must keep complete records of all experiments. The report forms a significant part of the coursework assessment (20%). If we want to teach and assess report writing skills, how do we ensure that students are learning the right skills, and not just making a single failed attempt, from which they will obtain only minimal feedback? We attempted to help students 'get it right the first time' by allowing them to see the assessment criteria. They know how many marks are allocated for what and hence know the relative importance of each section (it is amazing how quickly student adapt to the selection pressure of *marks awarded*). They also see a breakdown

of the important elements, which they pay much more attention to than in an assignment specification. For instance, it is difficult to get first year students to see the importance of correct referencing. It is easier to say 'there is 5% for correct referencing, this is the easiest 5% you will ever get, and learning it once will get you 5% for every assignment from now until the end of your degree. Here is how to do it right . . .' This applies to other oversights by undergraduates that examiners find continually, such as presentation of graphs (title, axes labelled, units, etc) and figures (labelled and numbered, referred to in the text).

Another method utilised for the laboratory report was to have two submissions for a single report. A draft report due date was held, when the report was *peer-marked*. Students were given a marking scheme with detailed criteria. We used tutorial sessions for students (about 16 per group) to analyse, mark, provide feedback and for the lecturer to make general comments. After reading the report, each section of the marking scheme was examined, with the lecturer giving general comments (using a specific paper, chosen from a willing student) on the expectations of that section. Students were asked to give feedback comments as well as a mark. At the end of the session, students were asked to consider the mark they had been given for each section, the reasons for the mark and to consider improvements. Most of the assessments were reasonable and disputed elements (for example referencing styles graphing techniques) gave an opportunity for the lecturer to address some of the areas about which students were unsure of the requirements.

This formative assessment was designed to serve two purposes: to give the students two bites at the cherry, so that they were made aware of the deficiencies in their initial attempt, and also to take on the role of marker, and hence see the task from a different perspective. Students were noticeably more critical in their analysis of other peoples work, and then could see the inherent problems in their own. Last year this method had some good feedback, but too few actually submitted the draft report. In 2006, there is a mark associated with submission of the draft report, if the draft is not submitted; the maximum final

mark is 80%. Hopefully this will make the exercise more valuable, by ensuring that all students submit a draft report.

OUTCOMES

While critical thinking may be difficult to foster in undergraduates, it is even more difficult to evaluate. Essentially students can be evaluated against a number of different criteria. We can see how well the students can use each element of the toolbox. This can be performed in a simplistic manner by testing the student's skills in each independently, or seeing how the toolbox is used to attack a particular problem. The students at the end of the LabVIEW and MATLAB sessions demonstrated competence in each of these areas. But are they aware that these tools can now be used for many different problems that they will see in their later studies? First year students have been found to be using LabVIEW and MATLAB to check assignment problems, and to generate graphs with numerical analysis for laboratory reports for other subjects. Clearly some students had added MATLAB to their generic problem solving toolbox. The evidence that some students are using the software taught in Experimental Methods in other units, where its use is not expected, is encouraging. But the best way to ensure that the programming elements continue to be used is to reinforce their use throughout the degree program.

Another important criteria is how the student's themselves see the knowledge they have acquired. Students evaluated the unit, and its delivery through a questionnaire. The responses were generally positive (there were no responses below the neutral point) and some responses in particular were encouraging. In particular students commented that they:

- Found the unit to be intellectually challenging
- Learned something valuable;
- Enjoyed participating in class discussions and being encouraged to ask questions.

Performance on assignments and exams, where the tasks and questions were designed to assess critical thinking, had mixed results. The report writing exercise was performed

well, with students demonstrating the ability to research a topic, present their own ideas and critically evaluate results. The exam showed some deficiencies in critical thinking, which may have been due to the pressure of the examination situation. It was obvious in the lead up to the exam (and at times in the unit in general), that some students were confronted by the non-standard delivery of the unit: a typical comment was *'just tell me what to do so I can do it'*. Some students appeared not to engage the thinking aspect of the course, continuing to focus solely on the *content*. For instance, an examination question where the students were asked to present an algorithm for a programming solution proved difficult, with many offering either complete code or spurious calculations.

In general the interaction in tutorial sessions was very satisfying, with students willing to engage new ideas and propose solutions to different problems. Not only was the assimilation of the ideas demonstrated, but it was clear that many students were thinking creatively about solving problems.

CONCLUSION

In the newly introduced unit, Experimental Methods, we have sought to be creators of a culture of critical thinking among students rather than just presenters of information. The unit uses a number of different presentation styles and learning environments. Weekly tutorial sessions combine short laboratory exercises, library sessions, computer lab programming and spreadsheet exercises, and traditional problem solving tutorials. There are also different environments within this structure, using a variety of laboratory equipment and settings (in an attempt to go beyond the 'staged' first year experiment), as well as a number of software environments. We hope that this exposes the students to the environments of a modern engineer, where not only the laboratory is important but the computer as well, and indeed the interface between computer and experimental apparatus (for instance, the computer as a data acquisition and control device).

The subject is used to foster generic student attribute skills and shape students ability to

collect data from a variety of sources and critically analyse that data. We believe that providing an early focus on critical thinking in a context that is meaningful, will allow students to progress with more confidence, and approach new areas of study and environments with the tools for success. However, further work needs to be undertaken to establish the effectiveness of embedding these 'tools' in students regular toolboxes.

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DEVELOPMENT OF LEADERSHIP SKILLS NEEDED BY ENGINEERS OF THE FUTURE

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ABSTRACT

Numerous reviews of engineering education have suggested that in addition to technical skills, engineers increasingly need to develop numerous generic skills including communication, team and interpersonal skills, essential to the development of good leaders.

Monash University has been running a Multi-Disciplinary Industry Project for the last decade, aimed at developing such skills in a realistic industry project. Projects focus on new product feasibility studies for companies. This requires the skills of marketers, accountants and industrial designers as well as engineers. It became apparent that weaker teams had poor leadership, and hence an elective seminar now titled 'Leading and Participating in Effective Teams' is offered prior to the project start. Emphasis is placed on communication and other interpersonal skills, team processes, planning, and decision making, supplemented by case studies of past projects, a panel session with former participants and a guest speaker.

The paper will summarise the feedback from students which has led to it becoming a highly valued learning process. Based on staff observations of recent projects and student feedback, a summary will be given of further modifications to be implemented in future.

INTRODUCTION

Batterham(1) and Dearing(2) stressed the importance to Australia and Britain respectively, of universities providing expert graduates for business to create economic advantage. Industry is rapidly changing and its need for graduates with diverse team, interpersonal and personal skills, along with their engineering understanding, are essential if they are to become leaders and effective managers.

Engineers Australia(3) indicated that in 2001,

over 40% of graduate engineers identified themselves as managers. Wearne(4) surveyed UK chartered engineers and found that 76% of respondents had substantial management responsibility. However, both employers and graduates were concerned that students have little opportunity to develop the necessary skills as undergraduates. Those who combine study and work experience are better prepared, but well structured cooperative programs are not extensive in Australia and are available to few engineering students.

Wellington(5) outlined the Monash University Multi-Disciplinary Industry Project (MDIP) in which students apply knowledge of their discipline to briefs from real clients, developing team and leadership skills as a result. The purpose of this paper is to look at the need for and ways of developing such skills, specifically those of the Monash MDIP supported by the seminar 'Leading and Participating in High Performance Teams.'

WHY SHOULD ENGINEERS LEAD?

Cole(6) emphasized engineers should lead innovation saying 'if any country is to compete in the global economic race, the role of the engineer must increasingly be that of the engineering leader.' He also stated that 'a merely technical education in the narrow compartments of the narrow professions is a totally inadequate preparation for engineering leadership.'

With more emphasis on economic growth through innovation, engineers with the relevant technical skills are increasingly required to lead project teams. However, Thamhain(7) pointed out that the effective manager needs to apply both established project management skills, and also 'provides overall project leadership for developing multidisciplinary teams, and fostering a climate conducive to involvement, commitment and conflict resolution.'

MANAGEMENT AND LEADERSHIP

Management texts identify widely varied definitions of management and leadership. Robbins *et al*(8) defined a manager as 'an organizational member who integrates and coordinates the work of others.' Fayol(9) saw management as 'planning, organizing, commanding, coordinating and controlling' but as Oblinger and Verville(10) pointed out, such views have changed saying 'We must now develop leaders - people who can create and communicate visions and strategies. Management deals mostly with the status quo; leadership deals mostly with change'. Mintzberg(11) saw management as involving interpersonal roles, (leader and figurehead), informal roles (spokesman and disseminator), and decision making roles (entrepreneur, resource allocator, negotiator). Mullins(12) felt management is concerned with formal structure and goals while leadership is more related to a person's skills rather than position, and is based on good communication and interpersonal skills, developing a shared vision and having the ability to motivate.

Wearne(4) identified 9 groups of skills required by over 80% of UK chartered engineers at all levels of responsibility. They placed leadership first and project management second in importance in their present jobs. He also flagged that most engineers are not well prepared for these roles although required early in their careers. Wellington and Clarke(13) showed that most MDIP graduates worked extensively in teams and felt that the MDIP had prepared them well.

ACADEMIC COURSE ORIENTATION

Clarke(14) identified that university education for professions like engineering is strongly science based, often neglecting essential knowledge from different genres, including leadership and team skills. Clarke advocated a constructivist approach to education based on the experiential learning cycle of Kolb(15) where each individual constructs their own knowledge based on personal experience, understood by discussion, interpreted by reflection and feedback and developed more deeply by ongoing experimentation.

Fink(16) observed that graduates from project based engineering courses at Aalborg University had slightly poorer skills requiring detailed disciplinary know-ledge than more conventional graduates, but are better communicators, cooperate better with those from different back-grounds and deal better with social, economic and environmental issues.

DEVELOPING LEADERSHIP SKILLS

A number of approaches can develop personal and interpersonal skills, the basis of leadership, such as Work Based (Cooperative) Learning, Double Degrees and Cross Disciplinary Electives, but Brennan *et al*(17) noted that these rarely develop good leadership skills. They cited a survey showing only 33% of mechanical engineers felt their course had addressed these issues and only 39% felt their work experience had redressed this lack.

Parks(18) advocated the Harvard 'case in point' teaching model where post graduate (mostly mature age) students learn by sharing and analysing their own and their peers' experiences and failures. This idea fits well with constructivism, but is of only limited benefit for undergraduates where few students have leadership experience.

Ammeter and Dukerich(19) analysed key elements of high performance teams in the US construction industry, finding a sense of belonging was the highest correlate with success, followed by leader behaviours, good communications and ownership of the project. Team leaders communicating direction and values and keeping team members informed of the project status were seen as critical.

Kelley and Caplan(20) studied engineers' success at AT&T's Bell Labs, finding no correlation between success and IQ, but high correlation between success and Emotional Intelligence, encompassing self awareness and interpersonal skills, the basis for leadership success.

THE MONASH MULTIDISCIPLINARY INDUSTRY PROJECT

In 1996, Monash University staff realized that

Item	2003	2004	2005
Working on a real project	4.53	4.67	4.48
Working for a real client	4.43	4.50	4.59
Working in a multi-disciplinary group	4.24	4.63	4.56

Scoring: 1 – very negative; 5 – very positive.

Table 1: Student attitudes to the MDIP

new product development was a goal for many engineering, marketing, design and accounting students. They believed that doing feasibility studies in multidisciplinary teams for real companies would have high motivation as shown in **table 1**. Staff also believed students' problem solving, team, communication and leadership skills would be greatly enhanced by such projects.

Teams of approximately 8, third year students from the 4 disciplines consult for local companies. By third year, they can apply a range of discipline-based skills to the project, but the MDIP enhances their skills in cross cultural communication, committee practices, project management, adopting responsibility for their selected roles, making decisions and making and presenting professional recommendations.

THE LEADERSHIP SEMINAR

Following the first projects in 1996, it was apparent that the groups with the most competent leaders were more successful. Accordingly, a 1 day elective leadership

seminar was held in the week prior to the start of the '97 projects. The 20 participants were highly positive, prompting the seminar to evolve into a 2 day off-campus retreat for all interested students not just team leaders, so the seminar has been relabelled 'Leading and Participating in Successful Teams' (LPST).

The constructivist learning model requires cycles of experience, reflection, dialogue, knowledge construction and experimentation to develop deep learning. Hence, for the LPST to be effective, it needs to be integrated with the 16 week experience of the MDIP, enabling a number of cycles of experience with the team, followed by reflection, discussion and formal and informal feedback from supervisors and peers, followed by the chance to adopt alternative approaches to team issues. The semester's interaction allows all team members to gain experience of undertaking a project making justified recommendations based on cooperative information retrieval and shared problem solving activities.

The Seminar 'Leading and Participating in Successful Teams'

The seminar from its inception has had an active learning focus and involves tutoring in a number of topics by professional psychologists from the Monash Counselling Service, in addition to a project management focus led by team facilitators. The seminar's formal activities are shown in **table 2**.

Day1	Introduction and understanding how teams work *	10:30 -12:00
	Team roles *	12:00 -13:00
	Personality types - interpreting and applying Myers Briggs results *	14:00 -16:00
	Case Study of Former Projects #	16:30 -17:30
	Panel – '04 students discussed their projects, answered questions.#	17:30 -18:30
	Dinner and after dinner speaker	18:30 - 21:00
Day 2	Effective Communication*	10:00 -11:00
	Giving and Receiving Feedback *	11:15 -12:00
	Dealing with Conflict *	12:00 -13:00
	Time Management, Mapping Critical Path. Problem Solving #	13:45 -14:45
	Market research #	14:45 -15:15
	Concurrent activities – starting all facets in week 2. #	15:30 -16:00

* Session led by Psychologist. # Session led by project facilitators

Table 2. Timetable for the LPST Seminar in 2005

Introduction and team building

A team skipping exercise with up to 8 students per team provides an excellent, fun ice breaker which allows a number of team skills to be later identified. After introduction of the forming- storming- norming- performing- adjourning model of team activity, students realize that group dynamics change during the semester, and periods of conflict are normal. Belbin(21) listed 9 team roles – coordinator, team worker, finisher, plant, monitor, implementer, resource investigator, shaper and specialist, which are discussed, allowing students to identify their own strengths and preferred roles.

The Myers Briggs Type Indicator (MBTI) of Personality Profiles

The importance of psychological profiles in determining team skills has been widely discussed (Culp and Smith 22, Varvel *et al* 23), so students complete an MBTI survey form prior to the seminar. The MBTI flags preferences people have for Extraverted or Introverted behaviour, Sensing or intuition (those who focus on detail or prefer the big picture), those whose decisions are principally based on Thinking logically or Feeling for others, and the Judgers who are organised compared to the more flexible Perceivers (Myers 24). The survey results are returned to the students to help them better understand personality differences and optimize team performance. Students are divided into groups to experience the different types in detail. This is rated as one of the most interesting topics of the seminar as most students experience totally new ideas which most find interesting and useful. The MDIP coordinator later uses the results in team allocation, working on the principle that diverse teams will be more successful (Neuman[25]).

Case Study and Panel

LPST delegates are formed into teams of 6 to 9 to explore a past project brief, and plan how they would approach it. Their ideas are discussed with the coordinator who provides insight into the approach used by the original team, outlining some of the pitfalls to avoid. Students from the previous year also provide their views on challenges they needed to overcome to achieve a good team performance, subse-

quently answering questions both in a formal panel and informally over dinner.

Meal Breaks and After Dinner Speaker

Breaks are critical for ice-breaking, developing rapport and increasing student participation. Dinner has been followed by an Industrial Engineering graduate of 20 years experience at levels up to CEO, giving an after dinner speech. She highlighted ways she had used the MBTI for dealing with difficult colleagues and how she managed new projects. Having a highly successful graduate exemplify key issues raised in the seminar has been excellent in reinforcing the value of the topics being discussed.

Communications and feedback

With 4 different disciplines and many ethnic groups participating, this is a particularly important session. Discussion of verbal and non-verbal communications and issues such as personal space, eye contact, gestures and expressions were discussed for both Anglo-Australian culture and also those of South East Asia, the main source of international students in Australia. A strong case was made for local students providing international students with more time to contribute without the locals filling all the available time. This concept was developed later by one African student who addressed the dominance of one Australian student in meetings, when as chairman, he put an item on the agenda to discuss the difficulty on international students in making their points due to limited quiet time. This leadership was praised by several of his Australian colleagues (though perhaps not the culprit) in their peer assessment and reflective reports.

It is all too common to hear students, and graduates complain that their work is not appreciated by tutors or management, as they rarely receive feedback other than negative criticism. In the 2005 LPST, giving both positive and negative feedback to enhance individual and team performance was highlighted. Graphical peer feedback is given in weeks 5 and 10 of the project itself and has proved to be of some benefit, but needs to be supplemented by direct praise or positive criticism from the team leader and facilitator as well.

Resolving conflict

Students rarely understand that conflict can be a positive experience, so this session provided insights into various models of addressing conflict and the difference between functional and dysfunctional conflict. Conflict resolving models such as competing, compromising, avoiding, accommodating were discussed with the benefits of win-win collaboration being clearly established.

Time Management, Mapping Critical Path, Problem Solving

Engineering students have experienced project management (including allocation of roles, time and resource management) in an earlier subject, but a refresher using examples from past MDIP projects was valuable, especially for the business and design students. Former projects where time was poorly managed, the critical path not followed or easy rather than good solutions were chosen, were discussed.

Market research role play

For engineers to know the features potential customers want in their designs, some form of market research is required. While this research is mainly a marketing role, engineering as well as business students enjoy discussing possible product features with the company and potential clients. Developing questioning and listening skills, and gaining confidence in interviewing are valuable skills, not just for the LPST, but for any leader.

Concurrent participation

The project requires a large workload and unless all members contribute throughout the semester, excessive loads will occur at the end for some students. Ways of planning the project so all team members are active from the beginning and ways of limiting procrastination are also developed. Engineers soon realize the need to identify key design variables at the beginning and accountants can't wait to start costing until a design is completed.

Evaluation and Future Improvements

Responses on the different sessions are shown in **table 3** using 1-5 Likert scales. In response to free questions about the value of

Session	'05
Team Building	3.6
Team roles (Belbin)	4.1
MBTI	4.3
Case study of earlier project	4.5
Discussion panel	4.2
After dinner speaker	4.2
Communications	4.4
Giving and Receiving Feedback	4.4
Conflict Resolution	4.4
Planning (Time management, critical path)	4.2
Market research	4.1
Organising concurrent activities	4.4

Table 3: Feedback, LPST Seminars '05

the seminar, 8 of 17 responses indicated that the seminar dispelled uncertainty about the subsequent projects and 7 indicated that the self knowledge gained was substantial. Understanding others, increase in team and leadership skills were also flagged by numbers of students. Such comments included:

'All of the interpersonal and team management skills that were taught were things I had never been taught formally, and I found them particularly useful. The case study was very useful because it felt like a dress rehearsal of the project and greatly boosted my confidence. MBTI things were fascinating.'

'I wasn't really aware that some people needed a 5 second gap before saying something. I just thought if they didn't jump in straight away they had nothing important to say.'

It is apparent from **table 3** and the comments that most existing topics are valued. However, observation of groups indicate creative problem solving tools and discussion on serious reflection would be worth adding. Student leaders should also be encouraged to consider the personalities in their teams and give praise or positive criticism more frequently.

CONCLUSION

The workplace of future engineers is certain to require a range of personal and interpersonal team skills and for many graduates, significant leadership ability as well. The concept of the

Multi-Disciplinary Industry Project has already been shown to achieve many of these. By involvement in the seminar *Leading and Participating in Successful Teams* students have an opportunity to learn, develop and enhance those personal and interpersonal skills leaders require. The seminar is the start of a process, and lays down the foundations for making the team based projects which follow, more successful. This experience at the undergraduate level, should enable these students to approach leadership in their subsequent careers with greater skill and more confidence than in the past.

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STRATEGIES FOR ASSISTING ENGINEERING STUDENTS WITH THEIR WRITING SKILLS

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ABSTRACT

The Materials Department at Imperial College has developed a number of strategies for improving student engagement and supporting deeper learning including a 'skills-based' tutorial system to help students to develop both core and transferable skills, Ortona(1), McPhail et al(2), McPhail et al(3) and Ortona et al(4). In this paper we describe a system we have developed to address the variability in writing ability of our undergraduate students, a specific issue that has become a source of concern.

The writing project was targeted at our first year undergraduate engineering students whose poor English was causing them to fail to reach their full potential. The project was undertaken in order to assess the extent of the problem and to determine the most efficient solutions recognizing that staff time is a limited resource. Our aim was to help make the undergraduates aware that the way they write and express themselves is vitally important both while they are students and in their future careers, and we have now put in place a sustainable support system to help them. The new system is designed to ensure that a poor grasp of the language can be identified early on in the course and then rectified, so that it will not be the cause of examination or coursework failure, underachievement or, as has happened in some cases in the past, withdrawal from the course. There is some evidence that a poor grasp of written English can lead to plagiarism, in extreme cases. The work had the following aims:

- To identify those students needing support.
- To improve the accuracy of the students' written English.
- To improve the fluency of their written English.
- To increase the range and accuracy of their sentence structures.

- To improve the organization of their ideas.
- To expand the range of their academic vocabulary.

A test procedure based on an existing laboratory class was designed to identify those students most in need of assistance. A series of tutorials were then provided for these students, together with a workshop and some one-to-one assistance. We found that the key issues were awareness and motivation and that in some cases significant improvements in written English were observed after just a few hours of help. We believe these strategies are transferable to other institutions and have the potential to ease the burden on both staff and students in universities and institutes of further education and to assist the students in their future careers.

INTRODUCTION

Generally most of the marks in an engineering degree arise from assessment by academic staff of the students' written work, for example exam scripts, laboratory and project reports, and so on, and indeed in our department over 90% of the marks are based on written work (including exam scripts). The overall outcome of a degree programme thus depends not only on what a student writes but also on how it is written. While these statements may appear to be obvious, many students have not reflected upon or fully understood their implications. Staff may mark down poorly written work even if there is no formal penalty in place in the marking scheme. This effect can be increasingly significant once an 'irritability threshold' has been crossed. Students are often not fully aware of the vital importance of careful analysis of the situation and an understanding of the requirements and expectations of the reader in producing an effective piece of writing. Furthermore they

often fail to perceive how important their writing will become in their future career. The skill of academic writing is the subject of many books (5,6,7,8) and was the subject of the WDHE conference in May 2006(9) '*a forum for participants to explore the implications of developing approaches to supporting student writing against the backdrop of wider HE and institutional agendas*'. The 'writing issue' is not unique to the higher education arena, of course, and a number of popular books have been written on the subject recently(10,11).

Our students typically have high academic ability but a large number are from overseas, particularly the Far East, and even among those whose first language is English there is a considerable range of skills in their standard of writing. Because of this broad spectrum in skill level at the point of entry and because students vary in the way in which they respond, any support systems which we put in place must be both flexible and efficient, allowing us to keep track of progress for each individual. For those who need a lot of help our College has an excellent English Language Support Programme (ELSP) but students need constant encouragement to make best use of the opportunities offered because of pressure of work and the time involved. As a result of this project we have arranged collaboration with the ELSP staff visiting the department which will be much easier for the students. Native speakers vary widely in their ability to write and often need help. Some have been encouraged to think that '*in science writing does not matter*' and the variation in quality of their work is disturbingly large. Even the accuracy which is so important in engineering may suffer from unseen ambiguities arising from careless writing style and this is something which we aim to identify early on (the first diagnostic test included provision for this) so that first and most importantly they are aware, and secondly the necessary help and encouragement can be given within the department.

In practice we have found that reaching an institutional pass mark in IELTS or TOEFL does not guarantee that the student has acquired all the writing skills necessary to thrive on the course although unfortunately many students believe that by passing their English language entry test that they have '*ticked that box*'.

Students presenting with the same IELTS/TOEFL score often exhibit a wide range of writing abilities. This last point may be affected by their personal attitude to the situation. Those concerned to improve their language skills will generally be able to do so but there are many who are convinced that it does not matter.

Our initial work reported at EE2004 involved a series of interviews that showed that many students think that the technical content of their reports is all that matters and that language and presentation are of little importance, McPhail *et al*(3). It appeared that some pupils had chosen scientific subjects at school because they felt that the quality of their writing would not matter, giving rise to a tendency not to read work through before submitting it. This idea may have been unwittingly reinforced at College by the fact that some of the tutors marking the reports paid little attention to the use of language and did not offer help to students who wrote badly. It should also be noted that the tutors themselves have varying levels of interest, enthusiasm and ability for assessing and correcting the written English of their tutees and that different marking schemes that place a different emphasis on the quality of the writing are a source of frustration and confusion to the students.

INVESTIGATIVE WORK

Our work focused on the sixty-six first year BEng/MEng Materials (Engineering) students in the academic year 2003-2004. At a practical level the testing and interviewing was conducted by Andrea Walker (AW) (UG office administrator) with help from Julie Hartill (JH) from our Humanities department and David McPhail (DM), the principal investigator. The strategy had the following elements.

Screening Assessment

Students in need of support were identified upon the basis of an initial screening assessment. The first laboratory report which each student submitted, a 'Materials Survey', was evaluated and each individual student was interviewed (by AW) to discuss their work

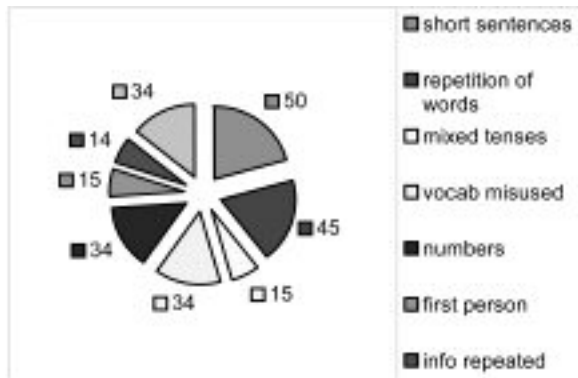
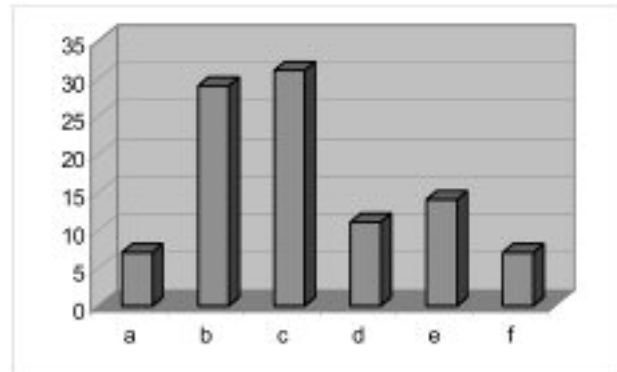


Figure 1: Percentages of occurrence of the most common faults in the written reports

and was offered help where necessary. Each report was evaluated and comments made on the use and quality of language and, following their interview, each student was asked to make changes where necessary before handing in the work to personal tutors for marking of the content. Only three out of sixty-six students failed to attend and some were interested enough to return with questions and to ask for help on several subsequent occasions. At the interviews each student was handed two sheets of information. In the first of these entitled 'Writing Skills', the student was shown why we had undertaken the research and wanted to help them, giving short positive reasons and advice, and emphasizing the importance for their future careers. In the second an outline of how to approach writing a report was given, with some brief indications of the common mistakes which occur and how to avoid them.

The results from the interviews are shown below in **figure 1**. Of the sixty-six students interviewed, thirteen required a lot of help with their English. The student reports fell broadly into three categories: those in which the English was poor, those in which the writing was reasonably good but which included many of the most common mistakes such as repetition, and those which were well written but would benefit from a few improvements in style. One of the main points to arise was the preponderance of short sentences which necessitated repetition of the subject over and over again. It was pointed out that by linking two short sentences it was often possible to cut out a large number of unnecessary words and to make the meaning much clearer. There was an obvious need for better instruction



- a Good overall, only very minor points need attention.
- b Good but needs more attention to detail.
- c Quite good but too informal/clumsy needs more care and thought.
- d Careless - sometimes lacking in coherence, logic, sometimes repetitive, disruptions to the flow.
- e Needs some help with English although not too bad. Sometimes misunderstands.
- f Needs a lot of help with the English language both in expressing and in understanding.

Figure 2: Percentage of reports which fell into the categories listed above

about the basic rules of formal writing as indicated in **figure 2**. It is recognized that the assessments below are indicators only but they give a good idea of the situation. Faults which came up again and again in the reports were as follows: short sentences leading to repetition, repetition of words, mixed tenses, vocabulary misused, numbers not written out, first person adopted, repetition of information in different sections, style too colloquial and informal. It is worth noting here that often the advice given to students is to avoid long, involved sentences but in practice there were very few instances of this.

After reading the reports the following categories were selected and are shown in **figure 3**.

Tutorials with ELSP

In order to help some of the students who had serious difficulties they were offered a tutorial with a member of staff from the ELSP (JH). Interestingly the take-up was relatively poor, suggesting that those students most in need of

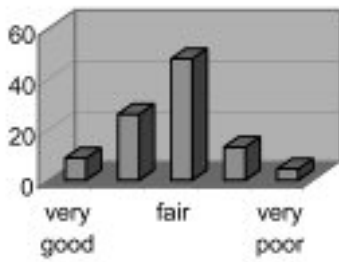


Figure 3: Students' description of their own writing ability (%)

help were the least likely to take up the offer, however those students who attended reported that it was very helpful indeed.

Workshop for all first year students

We organised a three-hour workshop session for all the first year students (after the screening assessment) which was well attended. We started with an introduction mentioning this project, emphasising again the need for self-help and asking for feedback. A series of slides were shown to explain each point. A film was then shown, showing three of our past students who are now in senior positions in engineering firms. They each spoke briefly about the importance of good, clear unambiguous speech and writing in the workplace and examples were given of the potentially disastrous results of lack of clarity in the field of engineering. We then asked the students to complete two exercises. In the first exercise the students wrote a letter of application in answer to a job advertisement which was handed out (15 minutes). In groups of about eight, the students looked at each letter in pairs, noting good and bad points, and making changes and comments (10 minutes). Each group of eight then had a general discussion on the corrections and comments made. They elected a representative to record good and bad points in two columns on an overhead projection sheet (10 minutes). The group representatives presented the results to the whole class, using the overhead and explaining the categories and the reasoning. Questions were taken at the end and a general discussion resulted. In the second exercise a

sheet with a piece of writing 400 words long was handed out and each student was asked to write a précis in 100 words on the paper provided (15 minutes). The paper was then passed to the student sitting on their right for comments (10 minutes). A prepared example was available on request and we then asked for questions and comments. The précis sheets were handed in at the end of the session. They were found to be very variable but it was felt that both the work itself and, particularly, the peer evaluation, were very useful. At the end DM gave a short talk, emphasising the importance of assessing the recipient and choosing the right approach and of ensuring accuracy at all times. It was made clear that there is always help and support available at a departmental level and from the ELSP and that we are always willing to give advice.

Questionnaire

Another of our approaches to the research was to conduct a questionnaire among the students concerning their writing ability. Most students did not reply to a question asking 'if English is not your first language do you need help to write fluently?' Of the eight who replied, only three students admitted needing help. The first student's comment was: 'I write with French expressions translated directly into English'. Two Chinese students wrote similar answers and thought that the main problem for them was in sentence structure and grammar, and one also added: 'lack of variety phrases and vocabulary'. When asked to describe their writing ability all twenty-three students replied. **Figure 3** shows that the majority think their writing ability is 'fair' or 'good'. When asked how they thought they might improve their writing eighteen students replied. Interestingly the two most popular answers were 'reading more' (twelve students) of which one specified reading 'well written reports for guidelines'. This suggestion encourages our idea of making a website available for students to see past reports that they can use as a guide. Eleven students replied 'writing more'. Giving students more chance to practise writing is something also emphasized in the literature and one example may be found on the Queen Mary and Westfield College website(12). Three students thought that having a greater

vocabulary would improve their writing ability but they did not specify how they could achieve that. Only one student suggested attending English classes as a good idea to improve writing. Most students were, therefore, willing to point out ways to improve themselves, even if they were not very specific, and most of them were aware of their level of writing ability. Most students, however, did not point out where their weaknesses lay and perhaps were not fully aware of them. A compulsory course text-book such as that by David Porter(13) is recommended.

Awareness

As we have indicated, the most important task is to create awareness in our students of the importance of good writing skills and to make sure that they realise the effect that their style of writing will have on the reader. It was noticeable that a considerable number of people had not considered adopting a different style and approach according to the purpose. It was also apparent that one of the main causes of poor report writing was leaving it until the last minute and not taking time to read, revise and edit.

Berthouex(14) makes the point that students must consider the emotional response of the reader. It is therefore important to involve members of staff in reinforcing the message to the students but the problem here is the inevitably wide variation in both ability and inclination among the staff themselves to do this. It was decided that simple guidelines would be given to members of staff to try to overcome the different standards applied to report marking. They will also be asked to discuss any problems with the student concerned and to monitor progress. Marking can be a negative experience if the student does not understand the mechanism on which it is based and if he or she does not receive some insight into how to improve. Students from one engineering department reported that different tutors used different marking schemes when correcting their lab reports with the effect that the feedback they received from the marked scripts became frustrating and confusing rather than constructive. We now hand out basic guidelines for writing reports at the beginning of lab sessions in addition to the

tutorial devoted to this at the beginning of the year. In the spring term when students have had more experience we run a workshop to help with report and essay writing.

Marking

According to some educationalists marking is something that can have a great effect on student motivation. Coupled with feedback and self- or peer-monitoring, marking can be a powerful tool in allowing students to develop insight into their own progress and development, Ortona(1). Many departments across Imperial College are trying to make their students aware of the importance of writing through different marking schemes and in the Materials Department it has been decided to implement a system whereby up to 25% of the marks for a lab report may be deducted for poor English in the second year. This will not be the case in the first year where the support system will be in place to ensure that students are both able to satisfy the criteria in their second year, and aware that it will be in place.

Cooperation with the language department and in-house help

There are many examples in the literature of successful cooperation between engineering departments and language specialists which have improved the level of written English in engineering students. The resources of the ELSP section in our Humanities Division are of course limited and the collaboration described here benefited from the Materials department 'filtering process' using an initial assessment, so that the ELSP assistance (JH) could be more focused. In reality such a process relies on the enthusiasm of a departmental champion such as AW prepared to offer both structured help and help on an ad hoc basis.

CONCLUSIONS

The research project described here has led to a strategy designed to improve the writing of our undergraduate students which may, we hope, be transferable to other engineering departments. One key element is to make

students aware of the importance of writing and to show them that their writing is their own responsibility. If they want to become professional engineers, or follow an academic career, they cannot afford to disregard the need for this skill. We are devising ways to promote awareness through marking schemes, workshops, feedback sessions and the cooperation of members of staff. Assessing the writing skills of our first year students in the course of one academic year has given us an insight into their different educational backgrounds and has allowed us to place them in different categories according to the support we feel they need. It has also pointed the way to a more efficient diagnostic procedure in the form of a test. First and second year workshops help us to raise awareness in students and also provide us with more experience on which to base the final plan which will help them to write effectively and well. The intervention of the ELSP staff in more critical cases is very welcome, and where possible it is recommended that the ELSP tutor visits the department and becomes known to the students. The deduction of marks for poor English in the second and subsequent years is an important factor. It is hoped that it will reinforce the advice given on good practice in producing a written report, and provide an incentive to achieve. We also hope to promote enthusiasm among at least some of the students who had formerly looked on writing skills as necessary but boring.

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