Breaking The Boundaries In Engineering Education By Incorporating Interdisciplinary And Inter-Gender Interaction In Final Year Projects

Aaron S Blicblau and Johannes P van der Walt

Swinburne University of Technology,
Hawthorn, Victoria, Australia 3122

Abstract

Final year projects serve as the capstone of a mechanical engineering course. These projects aim to subject the students to one final round of preparation for industry such that he/she will "hit the ground running". The final year project achieves this by bringing together all that the student has learned in one practical application. This improves the "marketability" of the student and demonstrates students' understanding of their fields of disciplines, as well as their ability to critically evaluate and synthesize materials across disciplines. An outstanding example of such a final year project in action is a formula style race car project supervised under the auspices of the Society of Automotive Engineers (SAE). To contribute towards the interdisciplinary nature of the project at Swinburne University of Technology, Mechanical-, Product Design-, Electronic- and Mechatronics Engineering students as well as Business degree students are involved in the technical development, construction, testing and marketing of the project. The group consists of both male and female students and the team manager is a female business student. In sharp contrast to the success achieved by these students in achieving engineering excellence in their final year of study stands the shaky start in engineering training of a second year group of students. This paper aims to highlight the causes of the poor start many students experience as well as emphasising the enormous progress made during the final capstone project.

Introduction

Final year projects have been an integral part of engineering education for many decades (Blicblau et al, 1998). The successes of these projects have been varied. Some have led to patents, international journal papers and even to PhD studies. Many, if not the majority however, is mediocre. Since the aim of a final year project is to prepare a student for industry such that he or she will require less training in the workplace and will "hit the ground running" quicker, it must bring together all that the student has learned in one practical application. Moreover, it has to teach students many lessons that they would not have learned during formal undergraduate training – team participation, leadership, responsibility, punctuality, perseverance, reliability, technical prowess, presenting and defending their design work, financial control and a myriad of other skills that one can only obtain in a real-life setting (Blicblau, 2000). To this end a large group of 22 students participated in the design, development, testing and competing of a Formula SAE race car at the Faculty of Engineering and Industrial Sciences at Swinburne University of Technology. In excess of 200 engineering faculties worldwide annually participate and compete in the Formula SAE project. The project is set up and run as a business, complete with a leadership structure, financial and marketing responsibilities, budgets, timelines and deadlines, presentations and personality clashes! Furthermore, the racing environment provides for an ambience of anticipation, motivation and enthusiasm.

Car design project teams are often gender biased towards males, but in this case the team business manager is both a female and non-technical specialist (completing a business qualification). The work outlined here shows how a highly skilled and motivated engineering team is successfully managed by an interdisciplinary student with formal business skills. To contribute towards the interdisciplinary nature of the project, Mechanical-, Electronic-, Mechatronics- and Product Design Engineering students undertaking degree qualifications are involved in the technical development of the car. Within this team both male and female students are engaged in engineering analysis, design and construction tasks. Whereas the engineering students have certain skills in design and analysis, the technical skills are complemented by team members with formal trade skills. This is seen as a necessary requirement for successful implementation of the project. Furthermore, as many engineering students are often lacking in relevant managerial and financial skills associated with project management, the integration of management-business degree team members will enhance the training of these students beyond what can be taught in the classroom (Blicblau, 2002).

Conversely, the integration of a non-technical manager (who is both a business student and this year of a non-traditional engineering gender) provides these students with invaluable experience in the managing arena, especially when it is male-dominated and technical.

Capstone Project Background

It is only at the end of three years of intense engineering study that students may commence a final year project. They will have completed 12 academic semesters, and at either one or two semesters working with industry in a scheme known as IBL (Industry Based Learning). The students may select a project from a list prepared by academic staff, or may suggest their own topic based on individual interest, or arising from their period of Industry Based Learning. The project may be university or industry based. It may take various forms in which technology, research and development, experimental work, computer analysis, industry liaison and business skills vary in relative significance. Students are expected to conduct literature and state-of-the-art surveys, formulate and define problems, generate and select solutions, and analyse and prepare designs. Where appropriate, students build and test their design.

The major aspects of the Formula SAE team and how it differs from the other project teams is that the project is undertaken by a large group from many disciplines as well as across many levels of academic expertise: students with technical knowledge from the TAFE sector, students with "hobby" knowledge form levels two and three of their academic studies, and where the students work either individually or in groups of two or three. To provide assistance in difficult areas, the SAE project is undertaken under the overall guidance of a staff member who meets on a daily basis with the students to discuss and assure progress (a schematic outline of the project details and its management is shown in the figure below. The students who participated in the SAE project over the last few years have been very successful. The team has won the Australasian Design Award once, came second in the same even twice, won the Engineering Testing Award twice and won several individual events. It also led the entire competition, including several international entries, by a fair margin in 2003 until a technical hitch forced their withdrawal midway through the very last event. It is clear then, that these project students have been performing at the top-end of graduates around the nation and even internationally.

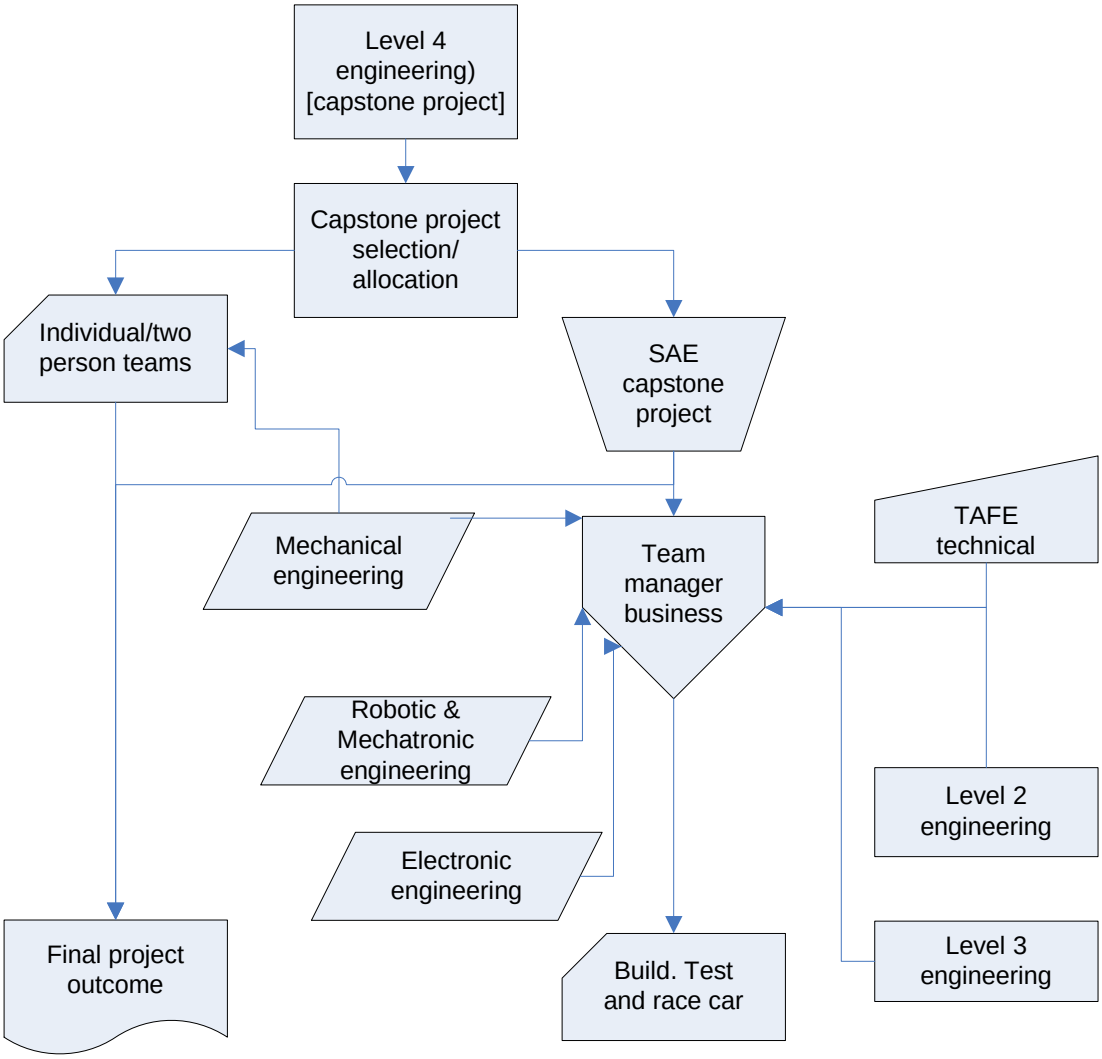


Figure 1: Outline of the project details and its management.

This success stands in sharp contrast to the fledgling beginnings students made whilst in their second year of study in the subject Thermodynamics 1. A survey was conducted on 54 participating students after 4 weeks of study into the first semester when it became clear that the vast majority of students were struggling to cope with the subject material. This in itself is a recurring annual phenomenon, however to confirm suspicions and to work towards a higher success rate, the survey aimed to identify the main causes of the problem. The same survey was conducted with the final year Formula SAE project group after one semester of participation. Whilst many of the results were expected, some were illuminating and some even completely unexpected and contrary to general consensus at the Faculty.

Survey Analysis

The survey for the fledgling group of 54 second year students (attached in the appendix) aimed to ascertain the root causes of student failure at the start of their academic career. It prompted the students with the following essential questions:

- Age

- Gender
- Week he/she fell behind in (after 4 weeks)
- Reasons for falling behind
- Workload perception
- Subject content interest
- Relative value of lectures and tutorials

The same survey was conducted with the final year Formula SAE project group with a few modifications of relevant questions. The results for the fledgling second year group was analysed for the group as a whole, as well as a separate group consisting only of the student group that indicated that they are coping well with the subject material. The results for both groups as well as the Formula SAE group are presented side-by-side for visual impact.

Age

As shown in Appendix B, the majority of the second year student group is 19 years of age, although 40% is older than this, and almost 20% is 22 years and older. This is significant as it is the same age as the majority of students in the Formula SAE group and therefore disqualifies age as a major factor in the maturing process of these students as will be demonstrated in the following sections. Furthermore, the entire group of successful second year students consisted of 19 year-olds whilst all the mature aged students experienced difficulty. This was contrary to common belief that mature aged students perform well. Whilst they do indeed excel during the final stages of their course, they definitely struggle initially to cope by virtue of their academic background and not due to lack of motivation.

Gender

Slightly less than 10% of the second year group consisted of female students (Appendix C). This figure is roughly the same for the Formula SAE project. However, perhaps not surprisingly, almost all of the female students belonged to the group of successful student. It is widely accepted that female students in engineering are much more motivated and mentally more mature than their male counterparts during the early part of their university careers.

Time (week) the second year student fell behind (evaluated after 4 weeks)

Despite numerous warnings from the teaching staff, it was hugely disappointing to see yet another group of second year Thermodynamics 1 students fall behind. Only about 6% did not fall behind, and about 70% fell behind within the first three weeks of classes despite weekly assessments and feedback from the teaching staff. Questioning the Formula SAE student group, almost 80% admitted that they fell behind in the same subject, whilst 23% claimed to have been up to date at the final week of classes. Hence it is clear that the Formula SAE group still largely consists of students who were underperforming significantly during their second year of study.

Reasons for falling behind

The next question aimed to ascertain the root of the problem. Half of the second year group indicated that a too large workload was the cause of their problem. A group of about 15% admitted to being lazy whilst a similar group cited part time work as the cause. Tellingly, less than 2% realised the real cause of their true predicament – poor time management (apart from laziness!). In hindsight, the Formula SAE student group overwhelmingly identified the real root cause whilst more admitted to having been lazy.

Workload perception
Students were quizzed about the workload in Thermodynamics 1 relative to their initial expectancy of the workload. Once again, despite numerous warnings from the teaching staff during the very first week of lectures that the workload will be substantially higher than what students will expect, almost 80% of the student group still underestimated the workload. According to their own admittance this is directly attributable to the "spoon feeding" style of learning they were used to in secondary school as well as first year at university – a real cause for concern! Contrary to the entire group, the smaller group of successful students overwhelmingly did not underestimate the workload, and it was clear from their work habits that they approached the subject in a significantly different way. The response from the Formula SAE group is telling of the enormous change of work habit that has occurred within that group.

Subject content interest
Students were asked to express their view on what is required to cope with the subject material. Alarmingly, over 40% of the second year group saw memorisation as a suitable approach to engineering. None of the successful student group or the Formula SAE group saw this as a viable approach. Again, students who admit to memorising subject material in favour of logical thinking confided that memorisation of subject material was their principal approach during secondary school and first year at university.

Perceptions of the relative value of lectures and tutorials
Students were asked to indicate how much of the subject material they managed to understand in the lectures and tutorials respectively. It is clear that the successful group of students used lectures as their primary opportunity for comprehending the subject material whilst merely reinforcing it through exercises during the tutorials. In sharp contrast stand the rest of the students who fail to capitalise on maximising their efforts during lecture time. Most illuminating is the response from the Formula SAE student group who has adopted this philosophy in its entirety!

Skill development through the Formula SAE Project
The Formula SAE student group were requested to express their opinion on the relative weights of the training they obtained during the project in terms of technical ability, practical skills, business skills and personal skills. Most revealing is the fact that, whilst their technical skills received the greatest improvement, their personal skills received the second largest boost. Under the heading of personal skills was understood all the skills a modern day engineer requires to function successfully in cooperation with management, peers, clients and the outside world. It is this level of skill development that sets a large group project such as the Formula SAE project apart from other styles of final year project.

Summary Comments

It was shown that, although most students in Mechanical Engineering make a shaky start into the study of the discipline of engineering, subjecting them to a large group project based on the principles and structures of a real world business enhances their real world engineering skills to an extraordinary high level. Whilst traditional final year projects are helpful, they fall far short of what can be achieved through a project such as the Formula SAE project.

It was also shown that mature age students often start off with a significant disadvantage. However, through the Formula SAE project it was evident that these students eventually excel.

It was clearly demonstrated that students wrongly see the cause of their study problems as a too high workload whereas it is an fact poor time management and failing to understand that memorisation is virtually worthless in a technical environment and that the ability to think rationally and logically about problems is the key to success. They also failed to understand the optimum relationship between lectures and tutorials.

The Formula SAE project and any other large multi-disciplinary project group, is a way to fast-track the student's final training into a single subject that forms an excellent pathway for students into industry.

References

Blicblau,A.S. and Steiner,J.M., *Fostering Creativity through Engineering Projects*, European Journal of Engineering Education, Vol. 23 No.1 1998, pp55-65

Blicblau, A.S., A Bias-Neutral Approach to Major Project Assessment in Mechanical Engineering, proceeding of the American Society of Engineering Education, June 18-21, 2000, St., Louis.

Blicblau, A.S., Multi Assessment Approach to Major Projects, *in* proc. AaEE2002, 13h Annual Conference Australasian Association Canberra, Australia, 30 September to 2 October 2002

Swinburne University of Technology – Mechanical Engineering: http://www.swin.edu.au/feis/mechanical/

Swinburne University of Technology – Formula SAE Team http://www.swin.edu.au/feis/fbr/

Appendix A – The Second Year Student Survey

Thermodynamics 1 Questionnaire

Please choose only a single response to each of the following questions.

My gender is:
□ Male
□ Female

My age is:
□ 18 □ 19 □ 20 □ 21 □ 22 □ Older than 22

About you as a student

1. We have finished 4 chapters this week (week 4). How up to date are you with the subject? I'm up to date with:
   □ Chapter 1-4
   □ Chapter 1-3
   □ Chapter 1-2
   □ Chapter 1

2. When did you fall behind?
   □ I'm not behind □ Week 1 □ Week 2 □ Week 3 □ Week 4

3. If you are behind, what would the reason be?
   □ I'm not behind
   □ Laziness
   □ Subject does not interest me
   □ Too much Uni work
   □ Subject too hard
   □ Subject being taught poorly
   □ I work part time
   □ Other (please state in a word or 2)

4. How do you experience the workload in this subject?
   □ About as I expected it to be
   □ Much higher than I expected
   □ Much less than I expected

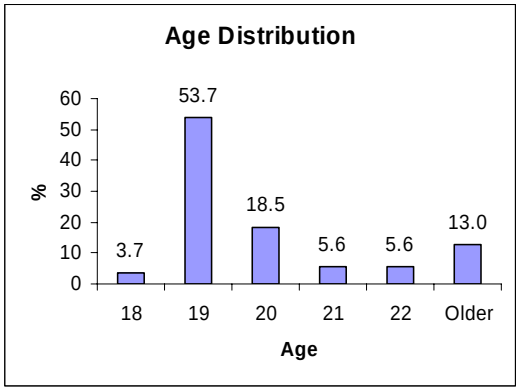
About the subject, its presentation and its value

5. How stimulating do you find the course content?
   □ The subject forces me to think
   □ The subject forces me to memorise lots of info
   □ The subject does not teach me anything

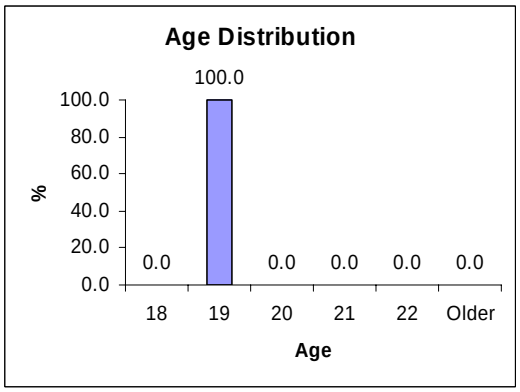
6. How do you rate the teaching quality?
   □ Very good □ Good □ Average □ Poor □ Very poor

7. What do you think of the teaching style?
   □ Good unique style □ Same as others □ Poor style

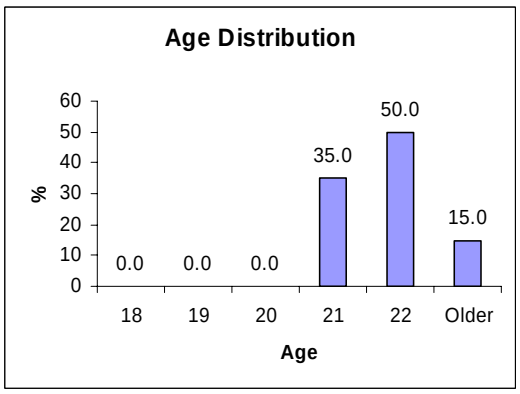
Appendix B – Age Comparison



The Struggling Thermodynamics 1 Student Group

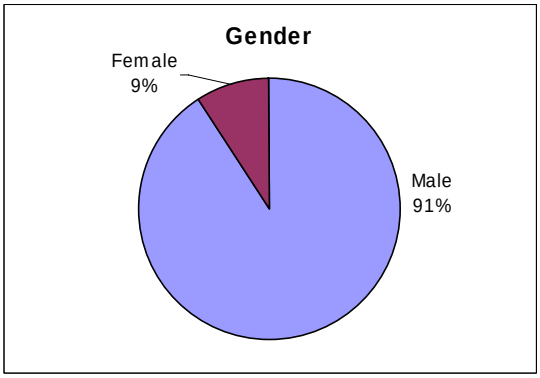


The Successful Thermodynamics 1 Student Group

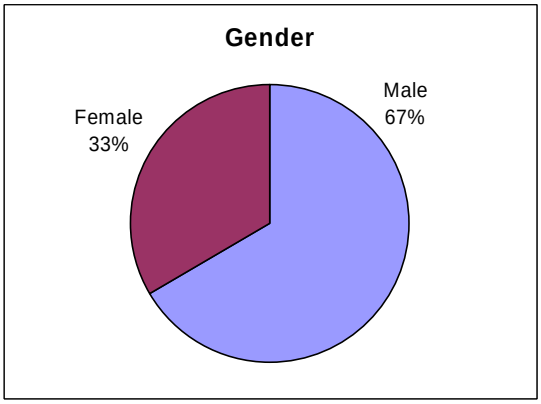


The Formula SAE Student Group

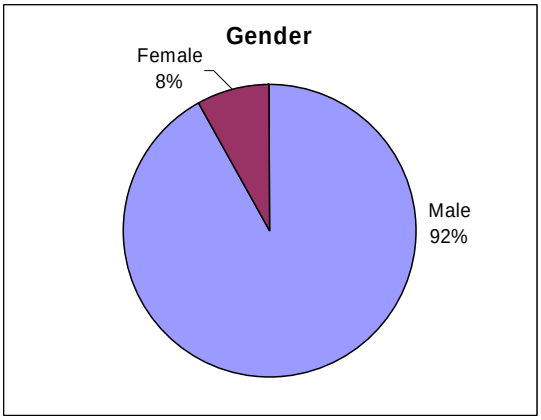
Appendix C – Gender Comparison



The Struggling Thermodynamics 1 Student Group

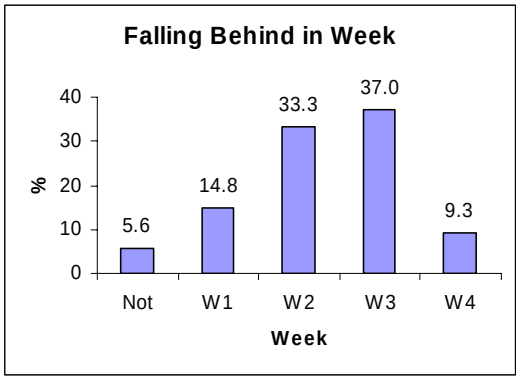


The Successful Thermodynamics 1 Student Group

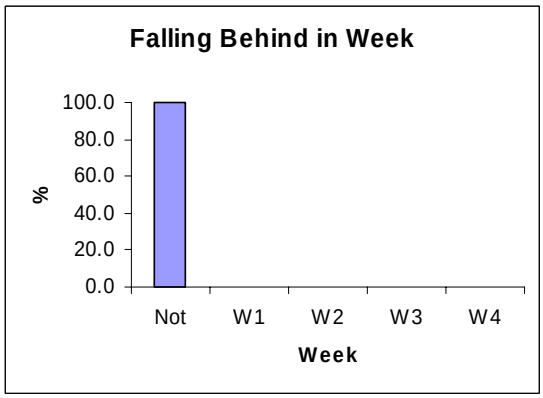


The Formula SAE Student Group

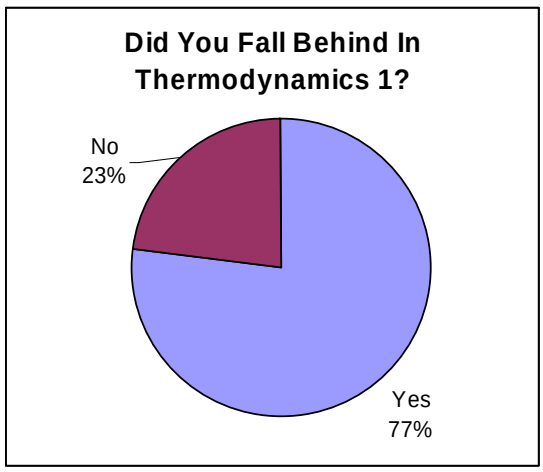
Appendix D – Time When Second Year Students Fell Behind



The Struggling Thermodynamics 1 Student Group

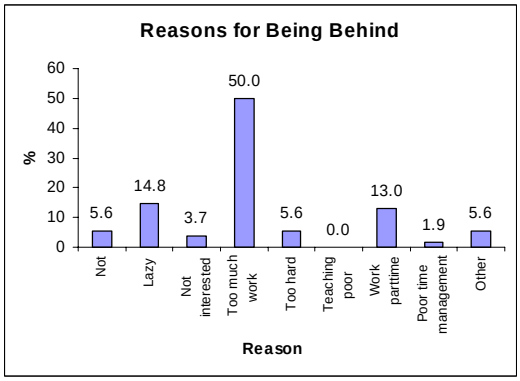


The Successful Thermodynamics 1 Student Group

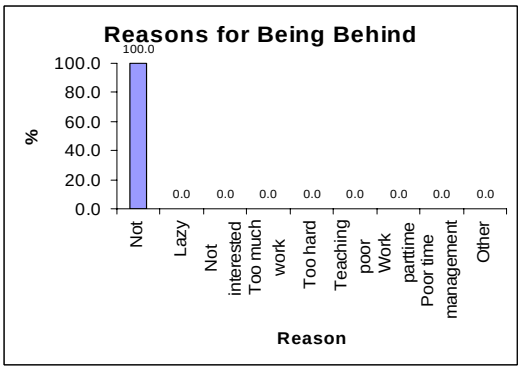


The Formula SAE Student Group

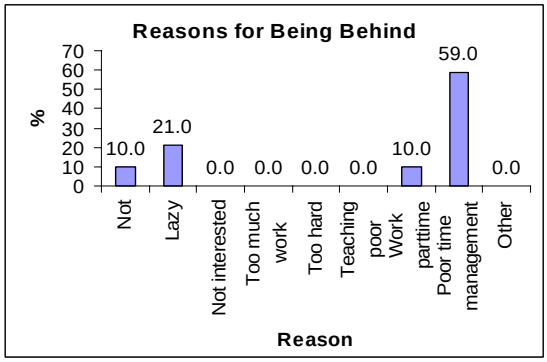
Appendix E – Reasons for falling behind



The Struggling Thermodynamics 1 Student Group

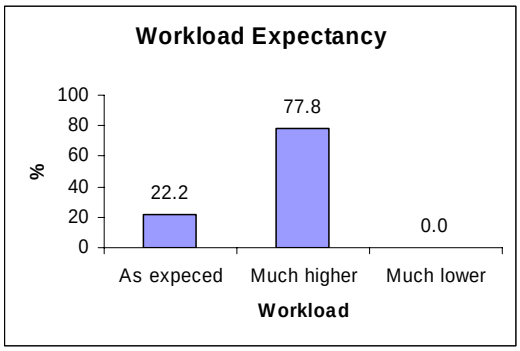


The Successful Thermodynamics 1 Student Group

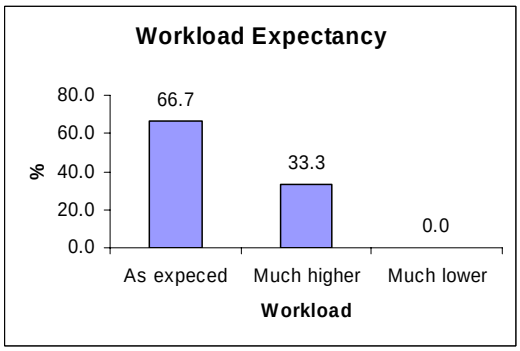


The Formula SAE Student Group

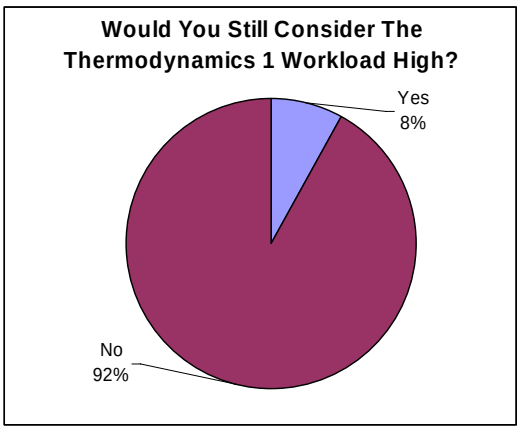
Appendix F – Workload Perception



The Struggling Thermodynamics 1 Student Group

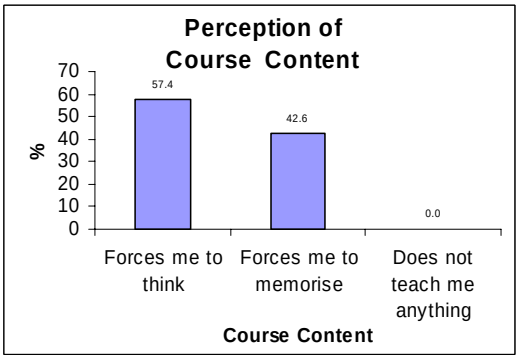


The Successful Thermodynamics 1 Student Group

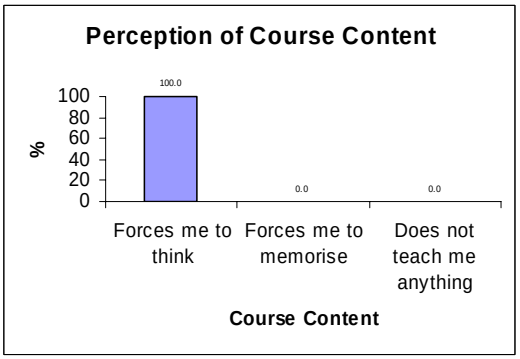


The Formula SAE Student Group

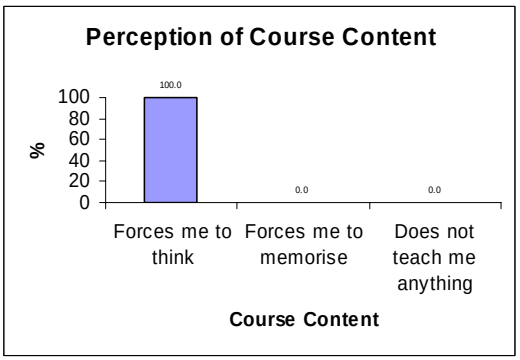
Appendix G – Subject Content Interest for Second Year Students



The Struggling Thermodynamics 1 Student Group

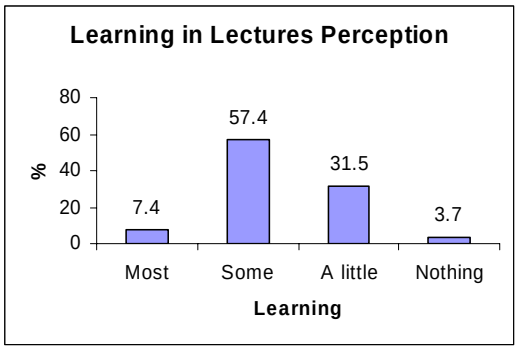


The Successful Thermodynamics 1 Student Group

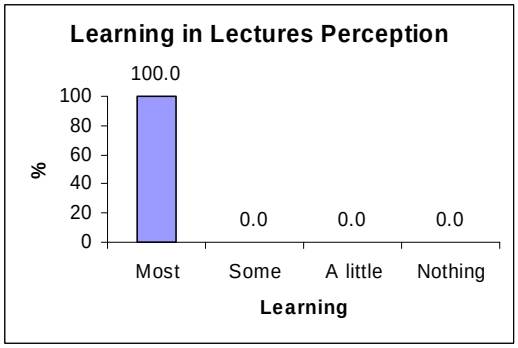


The Formula SAE Student Group

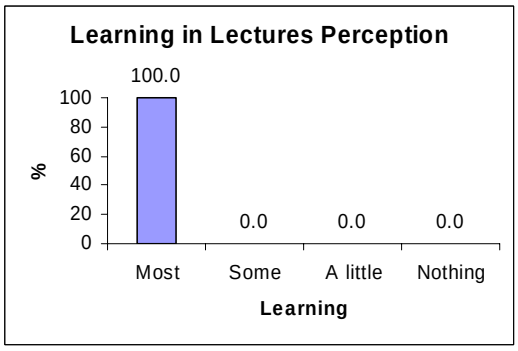
Appendix H – Teaching Quality and Relative Value of Lectures and Tutorials by Second Year Students



The Struggling Thermodynamics 1 Student Group

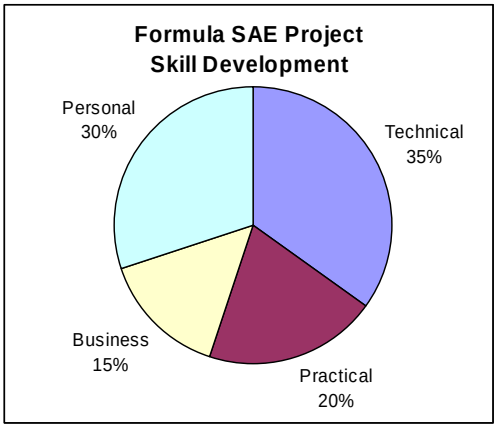


The Successful Thermodynamics 1 Student Group



The Formula SAE Student Group

Appendix I - The Formula SAE Student Group Skill Development Perception



The Formula SAE Student Group