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AEROSPACE ENGINEERING: INVESTIGATING STUDENT PERCEPTIONS AND INDUSTRY REALITIES

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Abstract

Aerospace students have different reasons for choosing their university program. Knowing their perceptions of the aerospace industry and their expectations in their future career can assist in determining the best teaching styles and program structures. A survey was conducted among aerospace students at RMIT University involving all four year levels in the Bachelor of Engineering (Aerospace Engineering) program. The results indicate that there is a mismatch between what the university tries to teach and what students actually learn. Students felt that they have been taught more about technical and analytical skills but less about business practices and ethics/social issues even though these were underlined by both academics and industry.

1 Introduction

Aerospace Engineering is a global discipline attracting high performing students with ambitions to work for high-technology companies. Nevertheless, research on student-learning outcomes unveiled that university graduates were not essentially developing the skills required by the industry. The research also pointed out that there is a lack of vital skills that are developed amongst university students, such as decision-making, communication, problem-solving, emotional intelligence, leadership and social ethics [1]. This is supported by research in the US on graduate attributes. It is found that there is a difference in opinion between industry and the universities on graduate capabilities. American industry needs the engineers who are able to solve open ended problems and produce quality design work whilst engineering schools are producing great scientists but average engineers [2]. Theodore Von Karman stated that 'A scientist discovers that which exists. An engineer creates that which never was'. It is the 'never was' that makes money for industry [2]. The undergraduate engineering program is an important phase in professional development. Although engineering schools aim at preparing students for the profession, they rely on academic traditions that do not always support the industry's needs [3]. It is crucial to understand the mismatch between graduate skills developed during university studies and those needed by the industry to re-design program structure in order to enable engineering graduates to be workplace-ready. At the same time, in order to enhance the learning experience and obtain better learning outcomes, student expectations must be recognised. The expectations are double-edged swords, increasing or lowering student and teacher outcomes in accordance with the positive or negative nature of the expectations [4]. Understanding the reasons why students chose aerospace engineering and their perception of the aerospace industry including employers' expectations, which universities mostly are not aware of, is the key that leads to better curricula and program structures. In this paper, "the competency gap" between aerospace engineering graduate attributes and industry's expectations is discussed. The paper also investigates the student expectations, why they decide to choose aerospace engineering and what they expect on the careers.

2 Graduate Attributes

The set of graduate attributes varies for different universities around the world [5]. Over the last decade, mapping and developing graduate attributes has obtained the attention from universities in Australia [6,7]. Universities are now aiming at producing graduates having the skills that are valued by employers. This adds to the particular nation's wealth and social capital. Several countries have developed frameworks and guidelines for universities such as the Accreditation Board for Engineering and Technology (ABET) in the US and Engineers Australia (EA) in Australia and have raised the importance of graduate attribute development in tertiary engineering education. Graduate attributes may be referred to as graduate qualities, generic skills, graduate capabilities or generic attributes, and have been used interchangeably. Graduate attribute amongst Australian and other universities are likely to vary, not only in terms of which attributes are included, but also the nature and level of attainment of the attributes [1].

3 Student Expectations

Besides industry views, identifying students' expectations is also important. Expectations are vital to education, the literature on motivation and performance notes that the expectations shape the learning experience very powerfully [8]. Studies also find that students who have high expectations perform at a higher level than those with low expectations, even though their measured abilities are equal [4]. In addition, expectations do not only exert a strong influence on the student, but they also affect how teachers behave towards the students. Furthermore, understanding students' expectations is also crucial to minimise the impact of school to university transition. Living as a university student is complex. A student sometimes has conflicting priorities in regard to family, current academic, social and paid employment responsibilities in order to achieve their university studies, whilst maintaining a lifestyle that satisfies personal and social needs. Students enrol in university programs for different reasons and the motivation to continue or give up their studies are complex [9,10]. Studies show that one-third of all students enrolling in Australian universities fail to graduate and over half of those students withdraw from their program in their first year (Australian Learning and Teaching Council). This may be because of the difference between the students' expectations and the experience that universities offer. This could arise from unrealistic student expectations of what will emanate during their university studies or because of misunderstandings associated with the university information. University teaching is based on assumed student needs and universities tend to provide information in accordance with the institutions' expectations, not those of the students [11,12]. Research pointed out that students preparing for university study may do so individually or via other channels. Many students however, experience an early 'reality shock' during their first semester rather than a smooth transition. Therefore, the mismatch between student expectations and experiences has an effect on their learning, retention, satisfaction and wellbeing (Australian Learning and Teaching Council). One way to increase student retention rate is to provide better alignment between student expectations and the reality of their first-year experience [12]. The alignment can be facilitated by either changing student expectations to better match the reality of the university experience or by the institution changing its approach to student engagement to better match the students' needs. It is important that universities are honest about the services they provide [13]. Effective communication assists in the formation of realistic expectations of what the university can provide the students, avoiding the leading to unrealistic expectations or offering promises which may not be met later [14].

4 Previous Studies

In 2009, the ALTC DYD Project was conducted in order to study and conduct a survey to more clearly define 'program outcomes' or 'exit standards' for tertiary education programs [1]. This leads to A Guide for Australian

Universities that can be used to define graduate capability for their discipline, eg [2].

During 2010 and 2011, members of Engineers Australia's Environmental Engineering College and the DYD Project Team generated a set of Graduate Capabilities for Environmental Engineering programs.

At meetings of engineering practitioners, participants were asked to write 'tasks that graduate engineers are expected to do in their company'. After writing many tasks each, participants were asked to work with others to cluster the tasks into meaningful groups.

The project team expected the clusters to represent the specialisations in environmental engineering, such as soil, water, energy, noise and air pollution. Instead, the clusters consistently represented six major work process skills consisting of Investigation; Modelling and Analysis; Integrated design and Implementation; Assessment of impact, risk and sustainability; Environmental Planning and Management; and Audit, compliance and review.

These process capabilities are one of three sets of capabilities: Technical Capabilities, Process Capabilities, and Generic Capabilities. These operate within a set of Environmental Engineering Contexts [15].

The Environmental Engineering Capability Cube shown in Figure 1a shows the interrelationships between the three sets of capabilities formed where the axes of the cube represent the Generic Capabilities, Process and Technical Domains. Figure 1b includes the Process and Technical Domains plus the Industry contexts[15].

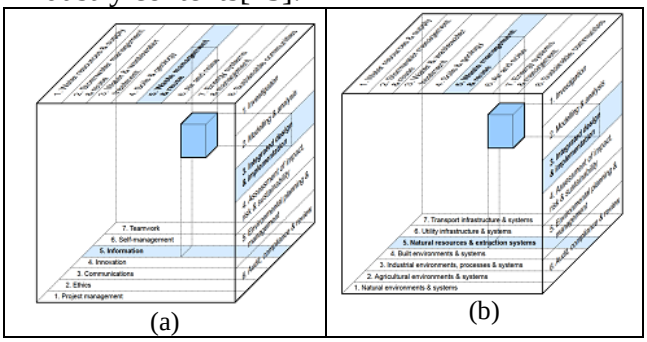

Fig. 1. Environmental Engineering Practice Cube [15].

Research supports the generic capabilities that have been defined by the DYD project [16]. Practical, interpersonal, professional, creative, engineering business related and entrepreneurial competencies are required in addition to the traditionally taught technical competencies. Of these, teamwork, communication, self-management, critical thinking, creativity, engineering business, professionalism and practical engineering skills are highly important [16].

Amongst these, applying technical theory was identified as a generic engineering competency factor. Nevertheless, it was ranked as the lowest importance. This could be as engineers may not be aware when using it. In contrast, it received most importance from the focus group participants.

It was seen that "applying mathematics, science or technical engineering theory or working from first principles" was essential when solving the physically realistic problems. It was viewed that the engineers needed a strong understanding of fundamental mathematics, technical engineering theory and science. Furthermore, in the survey, interacting with people in diverse disciplines/professions/trades" was rated as the second highest percentage for any competency. This tends to be assisted by fundamental knowledge in disciplines outside an engineer's core discipline. Not only generic elements are identified; the research has encompassed a systems approach, which is an engineering-specific element. Therefore, the communication, for example, including graphical communication might not be assumed to be necessary part of communication for all professions. This implies that engineers require an engineering version of the competencies that are called 'generic' as a result of their relevance to different types of employment. Some universities assume the generic competencies differently in different faculties [17].

The Boeing list of engineering attributes shows that engineering integrates many capabilities with knowledge and skills from many different sources [18].

- Good understanding of engineering science fundamentals.
- Good understanding of design and manufacturing processes.
- Multi-disciplinary, systems perspective.

- Basic understanding of the context in which engineering is practiced.
- Good communication skills.
- High ethical standards.
- Ability to think both critically, creatively, independently and cooperatively.
- Flexibility, the ability and self-confidence to adapt to rapid or major change.
- Curiosity and a desire to learn for life.
- Profound understanding of the importance of teamwork.
- DIVERSITY—wanted and needed!

The Airbus qualification criteria are in line with existing and future business needs manifested in the Airbus and Engineering Key Competencies [19]:

- Understand engineering science fundamentals
- Understand design and manufacturing processes
- Multidisciplinary systems perspective
- Business Acumen
- Project management skills
- International experience / Proven mobility
- Ability to work in teams (transverse, transnational)
- Good communication / presentation skills
- Flexibility to adapt to rapid changes
- Language skills (English being essential)

The desired engineering attributes given by Boeing and Airbus are consistent with DYD Project and EA Stage 1 Competency Standard. A good understanding of engineering science fundamentals can be compared to Technical Capabilities in environmental engineering DYD project and knowledge and skill base according to EA Stage 1 Competency Standard. A good understanding of design and manufacturing processes is equivalent to Process Capabilities in environmental engineering DYD project and engineering application ability in EA Stage 1 Competency Standard and good communication skills, high ethical standards and A profound understanding of the importance of teamwork can be compared to Generic Capabilities in environmental engineering DYD project and professional and personal attributes accordance with EA Stage 1 Competency Standard.

MIT conducted a survey to gain insights into what motivates US students to study aerospace engineering, how their experiences influence their career choice, and what their perspectives are on a future career in or outside of the aerospace industry [20]. They survey population is sophomores and seniors in undergraduate aerospace engineering programs across the US. The following is a summary of the RMIT University survey [21] and, where appropriate compared to the US survey [20].

5 Results and Discussion

Q1 Select 3-4 words that come to mind, when you think about the aerospace industry.

According to the results, most of RMIT aerospace engineering students thought that aerospace is high-tech. This is different from the data collected by MIT in 2012 where most of the US aerospace students viewed that it is aerospace was exciting. Nevertheless, the majority of students both at the US and RMIT considered aerospace as challenging. Local and international students think similarly about the aerospace industry.

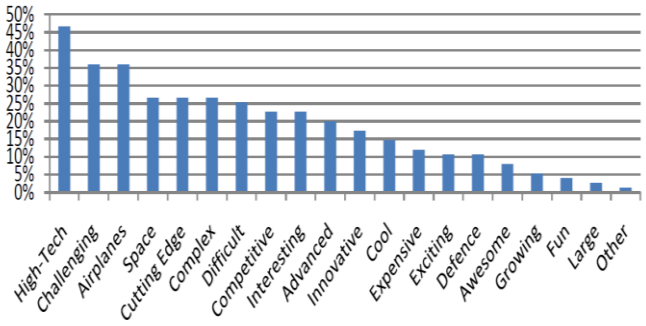

Fig. 2. Words students use to describe the aerospace industry.

Q2 What do you think of engineering?

When thinking of engineering, more than half of students thought that being an engineer allows them to do new things such as developing new technologies and environmentally sustainable buildings.

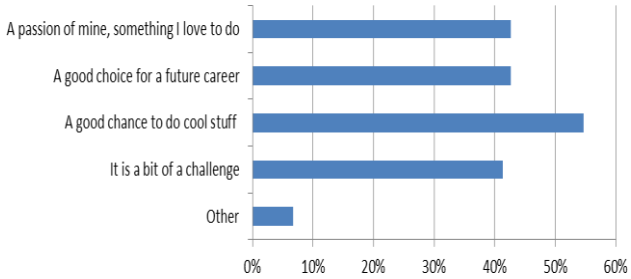

Fig. 3. What students think of aerospace engineering.

About 40% considered engineering as their passion, something they love to do and it provides a good and challenging career.

Q3 What made you interested in studying aerospace engineering?

There were various reasons why students are interested in aerospace engineering. They could be grouped into: aircraft/space/how it works, new insights in engineering/design, future career/life-style, passion of flight, knowledge of physics/ mathematics /mechanics/ building, and challenging. Being interested in aircraft and how it works took the highest percentage at 38%, followed by new insight in engineering and design at 18%.

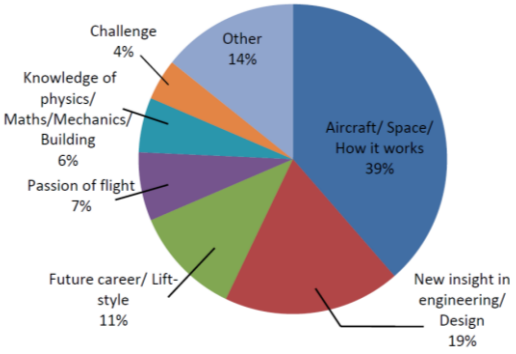

Fig. 4. Factors that make students interested in aerospace engineering.

Q4 If you were not to become an engineer, what other career would you have chosen?

If they were not to become an engineer, various careers might have been chosen. They could be categorised into: economist, business person, veterinarian, doctor/medical related, architect, scientist, mechanic, and pilot.

The three jobs most chosen by students were doctor (17%) followed by business person (12%) and pilot (12%). This reflects that students tend to choose careers that can generate a relatively high income.

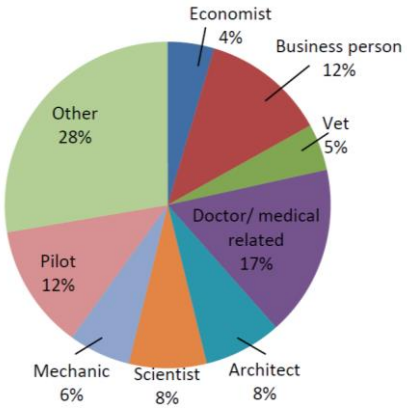

Fig. 5. Other career students would have chosen.

Q5 How old were you, when you first became interested in Aerospace engineering?

45% of the students became interested in aerospace engineering when they turned 14. This is consistent with the US-based (30%). RMIT students tend to become interested in aerospace later than the US students. Only 20% of RMIT students became interested in aerospace engineering when turning 10 compared to 35% of the US students.

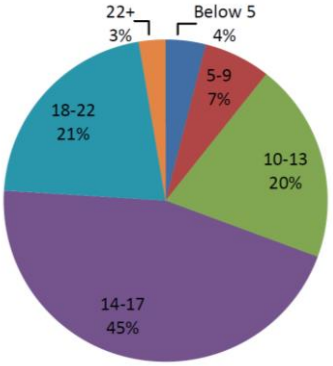

Fig. 6. Age when students became interested in aerospace engineering.

Q6 How many of your family members or close friends are engineers?

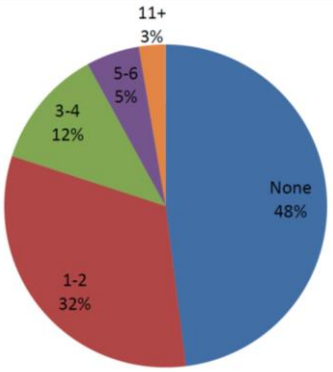

Fig. 7. The number engineers in students' family members and friends.

Almost half of student did not have an engineer as their family members or close family friends and at 32% of students had only 1-2 engineers in their family.

This is similar to the MIT's results which more than 80% of US students did not have or very few engineers as their family members. This suggests that there is no correlation with positive impressions of the aerospace industry, or propensity to enter the industry upon graduation.

Q7 Please rank your top four job requirements.

Students most consider salary when choosing a job, followed by work/life balance at 78% and 52% respectively and excitement at 33%. On the other hand, educational opportunities and flexible schedule were least considered by RMIT students as the desired job attributes. This is confirmed by the US study.

The aerospace students ranked salary, excitement, location and work/life balance as their first four desired job attributes. This reflects that basic needs such as income and living were first factors that students thought of. However, challenge and excitement were still important to them. This links to the reason why they chose to study engineering and were interested in aerospace, as it was challenging and provides excitement.

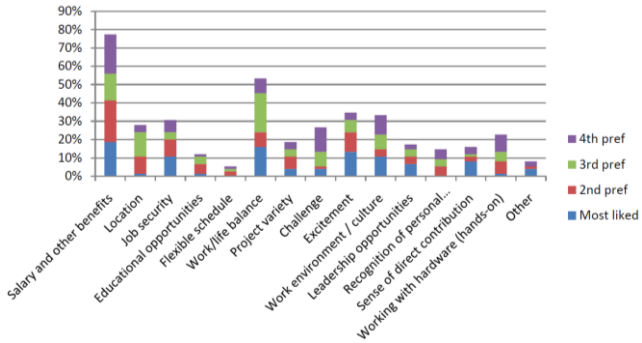

Fig. 8. Students' first four job attributes.

Q8 How important do you think each of these skills and abilities are in becoming a successful engineer?

Most of students thought that technical skills such as ability to frame problems, analytical skills, and research ability are important to be a successful engineer. Some generic capabilities such as communication skills, hands-on experiences, creativity and teamwork and leadership are also essential as well. In contrast, humanities, business practices, entrepreneurship were considered as less important for success in engineering careers.

Their thought may be shaped by university, as technical skills such as mathematics, sciences and group work were heavily developed through the institute during their studies but some business practices are slightly developed, as can be reflected by the question (Q9) on what skills are contributed to their developing in university studies. Therefore, they tend to emphasise technical skills more than other skills.

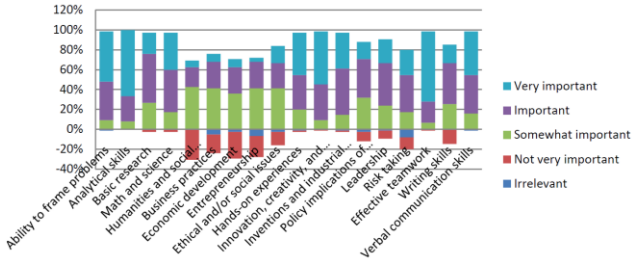

Fig. 9. Skills and abilities in becoming a successful engineer.

Q9 How has your university studies contributed to your development of each of these skills?

The results from RMIT and MIT are strongly consistent with each other. 100% of RMIT students and 99% of the US students viewed that mathematics and sciences are contributed in their university studies.

Furthermore, most of students at RMIT and in the US thought that ability to frame problems, analytical skills, basic research and effective teamwork including writing and communication skills are influenced in their university studies.

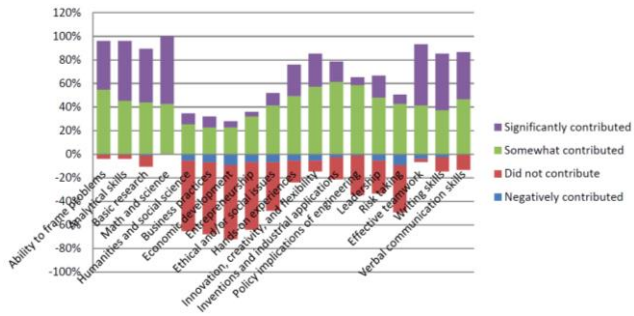

Fig. 10. Skills that contributed to student's development during university studies.

On the other hand, the high portion of students both at RMIT and in the US viewed that humanities, ethical or social issues and

policy implications of engineering are not contributed in the university studies. Amongst these more than half of students in the US and at RMIT viewed that business practices, economic development and entrepreneurship are not contributed in their university studies.

Q10 Please indicate whether each of the following has influenced your desire to work in engineering.

Overall, the study at RMIT goes as the same trend as what have been studied at MIT. Engineering classes, hands-on experience and faculty have influenced their desire to work in engineering. Non-engineering classes have also influenced the US students' desire to work in aerospace at a relatively high percentage of students. In contrast, more than half of RMIT students viewed that non-engineering classes do not influence their desire to work in engineering.

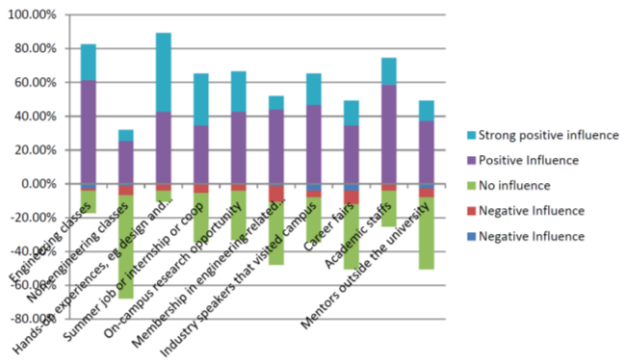

Fig. 11. Elements that influenced student's desire to work in engineering.

Q11 How does aerospace compare to other industries on the following job attributes?

Salary/benefits, challenge and excitement were favourable by most of students both at RMIT and in the US. Location, work/life balance and flexible schedule are considered as less favourable by the US and RMIT students.

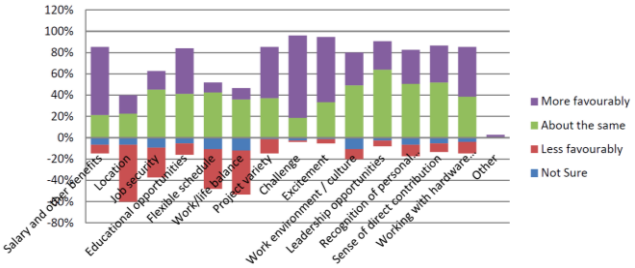

Fig. 12. Students' comparison between aerospace and other industries.

They might think aerospace engineers have to work very hard with a tight schedule and they also have to work far from home. It can be noted that more than half of RMIT students viewed that work environment/culture, leadership opportunities, recognition and sense of direct of direct contribution are about the same when compared to other industries. This can be linked to their desired job attributes, as salary, challenge and excitement were most desired by both RMIT and the US students.

Q12 How long would you expect to stay with the first company/organisation you work for after graduation?

The results from the US and RMIT were different. Both local and international RMIT students tended to expect to work with the first company shorter than students in the US.
58% of RMIT students expected to work in the first organisation at least 1 year whereas 52% of students in the US expect to work with the first company more than 5 years.

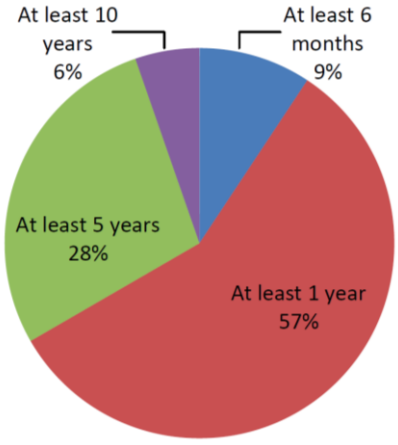

Fig. 13. Duration students expect to work for the first company.

Q13 Do you think the skills and knowledge gained in university studies will be sufficient for you to be successful in industry? Please explain why.

Overall, most at 53.70% of students thought that the skills and knowledge gained during university studies are sufficient to work in the industry. First year students were more likely to view that the knowledge and skills developed in the university studies are enough for industry work. In these figures, most of students who thought learning in the university is sufficient for industry said that although it is sufficient, there must be some training and

adjustment to align what have been studied in the university and the task that have to be done at work.

In contrast, 31.48% of students viewed that it is not enough for industry work because the industry requires certain amount of experience, and only theories have been taught in the university and there are much more to learn.

According to the results, there were some first year students who tended to be not sure whether knowledge and skills gained in their university studies will be sufficient in industry work or not. Some say that it depends on how much knowledge and skills will be still remembered after graduating.

Q14 What has been the most valuable learning experience at university to develop your skills for the workplace?

From all of the results, they could be categorised into: Research/Project, Group working, Computer experience, Internship, Experiment, Solving problems, exchange, Time management, Design process, Hands-on experience and Personal interrelationship. Group working took highest percentage as the most valuable learning experience at university.

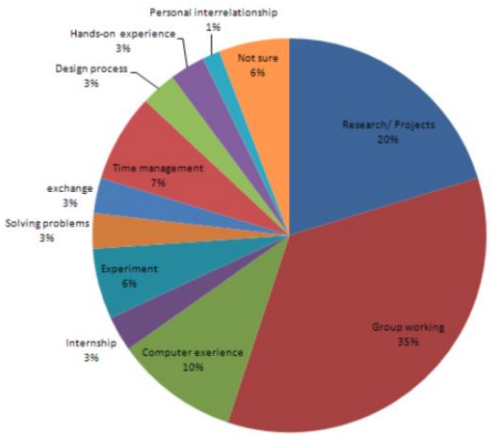

Fig. 14. Most valuable learning experiences at university that develop student skills for the workplace.

This is followed by research or projects that 20% of student thought that it is valuable learning experience during their university studies. Furthermore, Computer experience such as CATIA, FE, CAD and ANSYS took the third highest percentage at 10% of students who viewed that it is most valuable learning experience from university. Amongst these figures, higher portion of first year students than that of third and fourth year students were not sure and do not know what is most valuable experience at university.

Q15 What else do you think the university needs to do to help students in the transition to work?

It could be grouped into: credibility of university, technical and software skills, internship/work placement, practical assignments, hands-on projects, guest speakers, Relationship with industry and Professional mentor. Internship took the highest percentage at 39% of students who thought that university needs it to help students in the transition to work.

Hands-on projects took the second highest percentage at 17% of students thinking that hands-on projects are essential for students for better transition to work. Practical assignments were also considered as something important that university should provide to students in order to prepare them to industry work.

This is consistent with the valuable learning experience and the things that universities need to do to prepare students for a better transition to work, as internship, practical/technical skills and hands-on experience.

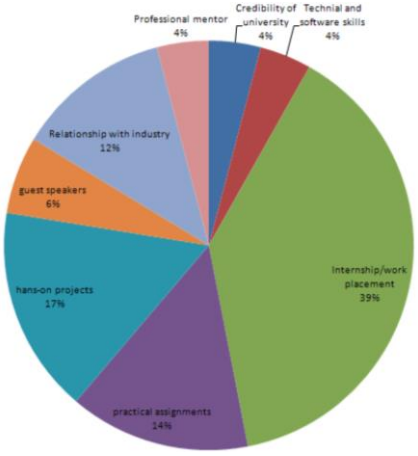

Fig. 15. Elements that the university needs to do to help students in the transition to work.

Q16 What kind of work do you expect to do when you start working after graduation?

This could be categorised into: general stuff, design/analytical, maintenance, aerospace, engineering, system, computer/software, research, pilot, document, trainee.

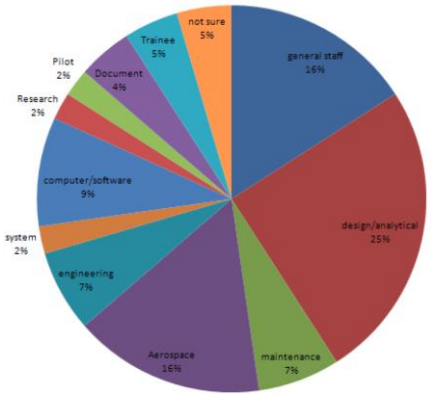

Fig. 16. Work that students expect to do when they first start working.

Design/analytical was most desired job by 25% of students when starting to work at the first company. General stuff and Aerospace engineering took the same portion at 16% as the job that students expect to do as their job at the first company. This suggests that students desired to work in a company that provides aerospace-related and design jobs as this might be influenced from their university studies; however, some of students were not confident in their knowledge and skills and needed some experience in industry work first.

Q17 Are you excited/looking forward to beginning work after you graduate or are you just going through the process and not sure what you will be doing once you graduate?

Most students (57%) were excited and looking forward to beginning work after graduation. About 43% of these students were excited to work but have some concerns. For example, they were not sure what exactly they have to do or to be responsible for. In addition, they felt that opportunities to work in aerospace industry are very limited. 28% of the students are not sure what they will be doing after graduation.

Q18 What percentage bracket do you give yourself of finding an engineering job within a year of graduation?

The percentage brackets of 20%-40%, 40%-60% and 60%-80% of getting an engineering job took about the same percentage at 24%, 27% and 27% of students respectively. International students were slightly more optimistic than local students, as 30% of them gave 40%-60% and 60%-80% to get an engineering job whereas 23% of local students gave 40%-60% and 60%-80% in find an engineering job respectively.

International students are more confident in finding an engineering job (80%) than local students. When breaking down to reasons why student were not confident in finding an engineering job, 50% stated low GPA and lack of experience in industry work. Some of them view that because of competitive environment, the positions available for them are very limited and some of international students viewed that nationality and immigration are the significant concern for them as well. In contrast, when looking at students who thought they will get an engineering job at more 60% of confidence, the reasons for that was they had high GPA. Some said that aerospace engineering is flexible and can be adapted in a wide field of career. Furthermore, some students who had experience or used to have an internship with the top company were more likely to be confident to get an engineering job.

6 Conclusions

The project reflects what students, university and industry think. Most of students come to study aerospace engineering because it is exciting and challenging and gives them opportunities to do stuff that will be beneficial for people. They reflect their perspective on the aerospace engineering education that technical skills, analytical skills, science and maths are contributed in their university studies. In contrast, generic skills such as business practices, economic development and ethical issues are less likely to contribute their development during university studies. From the industry's and academics' point of view, generic, process and technical capabilities are stressed and underlined. Most of capabilities defined by both academics and industry are consistent. Nevertheless industry emphasises more on connecting and coordinating with people and networks outside. Likewise, structure and statics are stressed by academics. Apart from this, aerodynamics and aircraft system are underlined by industry. This

indicates that there is a little mismatch between industry and academics. Furthermore, there are some pitfalls in teaching that can be reflected by student survey. Students feel they are not taught much about some generic skills, particularly ethics, business practices and economics, even though they are stressed by academics. This may lead to new curricular design and improvement of aerospace engineering education to provide the courses that can meet student expectations together with industry's needs.

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