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Active and integrated learning is important for professional success, so say our alumni!

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Abstract
A recent alumni survey carried out on the alumni of the past 25 years of the Faculty of Aerospace Engineering of Delft University of Technology shows that in their professional careers, alumni rate their active and integrated learning experiences on the same par as mathematics and mechanics in terms of their usefulness in their current job irrespective of their career path being an engineering managers or an engineering specialist or both. It can therefore be concluded that both core subjects and integrated and active courses such as design exercises are both equally important for engineers in the workplace and that they do not have to be mutually exclusive.

Key words:
Active learning, Alumni research, Competencies, Career paths

I INTRODUCTION

In 2000 the American Accreditation Board for Engineering and Technology (ABET) carried out a massive overhaul of its accreditation criteria (Engineering Accreditation Commission, 2000). As part of that overhaul universities were encouraged to engage more with their constituencies. With that they meant amongst others the employers of their graduates, the alumni themselves, the government and society as a whole.

In order to address this need, as part of a PhD project on the success of aerospace engineers, a large survey was carried out in the summer of 2005 among some 1800 alumni of the Faculty of Aerospace Engineering of Delft University of Technology who graduated between 1975 and 2000. This particular group was selected as they are the group of graduates who at time had been working for at least five years and

who would be able to look back at their degree and be able to reflect on the usefulness of their learning. Of the 1800 people approached some forty percent responded.

This paper focuses on those results from the survey, relating to their educational experiences and particular their experiences with active learning and how that relates to their career path as a professional engineer.

II THE CAREER PATH OF AN ENGINEER

It has been argued by many different people (Landis, 1971; Spurgeon, 1997; Covert, 1992) that engineering graduates upon entering the work force embark on one of two career paths: the *engineering manager* and the *engineering specialist*. Others (Pinelli et al., 1995) however, argued that this is not the case for aerospace engineers. They are the all-knowing, all-capable engineer: part scientist, part engineer and part manager. No distinct career path can be attributed to aerospace engineers.

II.1 Defining engineering career paths

For the purpose of this research two career paths for engineers were defined:

The *engineering manager* who is defined as an engineer who is in charge of the process leading to the product. They generally have to look at the bigger picture and are not as specialised although they have a broad technical knowledge. They typically have taken up a position of responsibility, such as manager, director, chairman, etc.

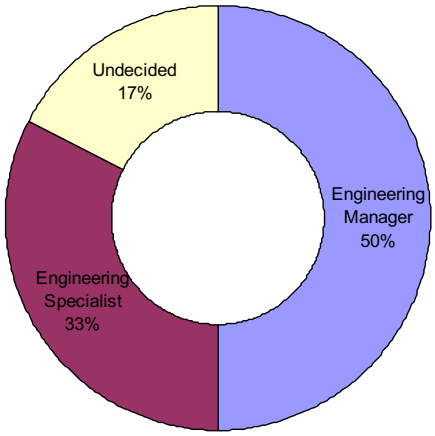
And the *engineering specialist* who is defined here as an engineer who either works within a company or a research institute and is an expert in a part of engineering science and is not really involved in the running of the business or the institute only in its product. They are individual contributors. Product in this context could mean anything from aircraft parts to Finite Element Calculations. Typically scientists at universities, researchers at research institutes or research and product development departments, etcetera, fall in this category.

II.2 Results

In the questionnaire the alumni were given both of the definitions above and asked to categorise themselves. Figure 1 shows the results. Looking at figure 1 it can be observed that the all-knowing, all-capable aerospace engineer Pinelli (1995)

describes does exist but does not apply like a blanket to all aerospace engineers. Fifty percent of the engineers consider themselves to be engineering managers, Thirty-three percent consider themselves to be engineering specialists and only

Figure 1:
What type of engineer are you? (N = 677)



seventeen percent are undecided and would fall into Pinelli's category. However that still makes up almost one-fifth of the population indicating that amongst aerospace engineering graduates there is a distinct group of very capable people who can do almost any job within engineering.

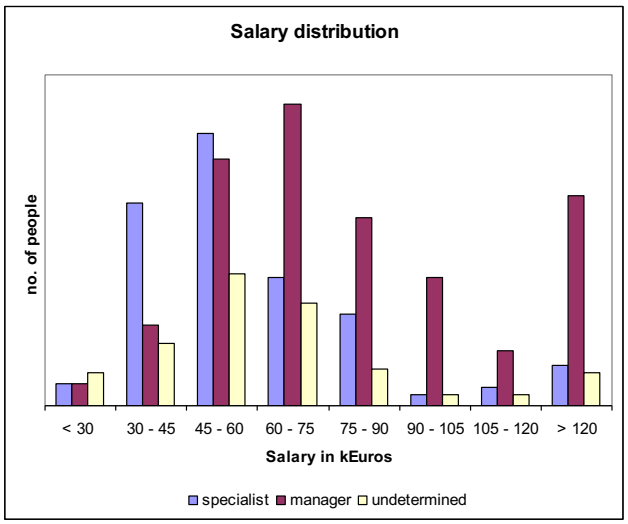
From this it can also be observed that many engineers pursue a management career rather than actually practising as an engineer, although many still work in a technical environment which requires an engineering degree as can be seen from table 1, which shows the requirements for an engineering degree and an aerospace engineering degree for their current position.

Table 1
Type of degrees require for current position (N=678)

	Engineering degree required?		Aerospace Engineering degree required?	
	Percent	Cumulative	Percent	Cumulative
Yes	68.3	68.3	22.4	22.4
No	31.7	100	77.6	100
Total	100		100	

The relatively low number of engineering specialist confirms a worrying trend. Governments and industry in Western Europe and North America alike have recently called in several press releases for more qualified engineering specialist. However, figure 2 may shed some light on the reasons why there are few engineering specialists.

Figure 2
Salaries of the different engineers



It can be seen from figure 2 that engineering specialists are relatively low paid as opposed to the engineering managers, making a career as an engineering specialist financially less attractive. If governments and industry are serious about dealing with the shortage they may want to address the remuneration of engineering specialists. However a recent personal communication of the author with several key figures within the aerospace industry indicated that they were not yet willing to pay engineering specialist a better wage, leaving the better paying managing track tempting potential engineering specialist away from where they are most needed.

III EDUCATIONAL EXPERIENCES

The respondents were also asked to name a maximum of 3 courses during their degree from which they still benefit today. This was an open ended question. The results in table 1 were achieved by first collecting all answers and then grouping them according to themed courses.

Table 2
Courses from which I still benefit today (N=1252)

	Percent	Cumulative
MSc Thesis	18.9	18.9
Internship	11.7	30.7
Calculus etc.	10.4	41.1
Design Exercises	9.7	50.8
Structures courses	7.8	58.6
Mechanics	6.9	65.6
Management	6.8	72.4
Communication skills	5.6	78.0
Materials	5.4	83.3
Computer & Programming skills	4.6	87.9
Aerodynamics	4.1	91.9
Aircraft Performance	3.1	95.0
Aircraft stability and control	1.7	96.7
Manufacturing	1.4	98.1
Maintenance	1.0	99.1
Space	0.9	100
Total	100	

From the table it can be seen that of the first five courses listed, three are what can be referred to as integrated and active learning courses. The MSc thesis and the internship are both problem-based learning exercises. Although carried out alone they work as a part of research group or product group who work on similar problems and must interact with others. That those two activities come out top in itself is not surprising. MSc thesis work often takes place in industry or in the laboratories and often closely resembles a real job. An internship of course takes place in industry and allows students to prepare themselves for their professional life.

But firmly in fourth place are the design exercises which are team-based, active learning experiences. It is interesting to point out that many of those exercises already existed in a team format long before active learning and project-based

learning were introduced. It clearly shows that alumni value their active learning experience in their professional career and that they do not see it as a "fashion fling" of educationalist.

Furthermore it can be observed from this table that not only are active learning and integrated learning courses still deemed important by our graduates in their current jobs also the fundamental courses such as mechanics, structures and mathematics are still deemed very important. One can conclude that teaching fundamental courses side-by-side to active and integrated learning courses do not bite each other in fact they go hand-in-hand in the workplace and should really go hand-in-hand at university also.

One final observation can also be made. The first ten courses on the list do not appear to be aerospace-related at all. This is of course not entirely true, as many items in the top ten are definitely saturated in aerospace content. The structure and material courses are aimed at optimising for conditions necessary in aeronautical and space design and MSc theses and design exercises have distinct aerospace themes. However, the more specialised courses in aerospace do not seem of much practical use in their professional life and could therefore possibly be integrated into the active learning experiences.

IV CONCLUSIONS AND RECOMMENDATIONS

Aerospace engineers themselves are very diverse and capable people and therefore very employable. Some seventeen percent appear to be able to do everything, indicating that they are both specialist and managers as Pinelli et al. (1995) described. It can also be concluded that only thirty percent really become engineering specialists, the new inventors and technology pushers of the future. This is a worrisomely low percentage given recent press announcements by European and North American governments and industry alike that a shortage of skilled engineering specialists is causing them great concern. Perhaps more needs to be done to tempt engineering graduates into an engineering specialist career track. At the same time it is good to see that many of our graduates do stay within engineering judging by the amount of alumni indicating an engineering degree is required for their position.

Active learning and integrated learning specifically in the form of design exercises are as important for engineers in their professional career as fundamental courses such as mechanics and mathematics. Both must therefore be incorporated in a successful engineering curriculum. Very specialist aerospace courses may be very popular at university and serve as a motivator to get through some of the more

fundamental courses but serve little purpose in an alumni's professional career. It may therefore be more efficient to integrate gaining this knowledge in to active and integrated learning projects.

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