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The Secret of their Success: What factors determine the career success of an aerospace engineer trained in the Netherlands?

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Introduction

Although engineers are educated with a vision that they can become successful, very little research is done into how engineers become successful. What is it exactly that makes one engineer more successful than another? And what consequence does that have for the way engineers are educated? This is becoming even more important taking into account the new ABET 2000 criteria[1], which state the need for a BSc program that it has a process in place that periodically evaluates its objectives based on the needs of the program's various constituencies. The constituents named in this criterion can be perceived to consist of various parties including the government, industry and alumni. A good description of the alumni population, their achievements and their employers as well as their opinion on the educational program will help to ensure (re-) accreditation.

This paper reports on the start-up phase of a PhD research at the Faculty of Aerospace Engineering at Delft University of Technology in The Netherlands into the success of its aerospace engineering graduates. A list of competencies was compiled based on literature and put to an expert panel of Dutch aerospace engineer employers for comments to see if the same success drivers apply in the Netherlands as they do in the United States.

The career track of an engineer

Several sources in American literature, amongst others Landis[2], Pinelli[3], Covert[4] and Spurgeon[5], feel there are two or three career tracks for an engineer to follow. It can be expected that there will be a different emphasis on how success is measured between the career tracks. In this research a distinction is made between two career paths an engineering graduate can follow which is displayed in figure 1.

In this the engineering specialist and the scientist are grouped together in one career track as individual contributors as that seems to be the common accepted definition in literature (See for instance Landis[2] and Covert[4]). It might be worthwhile to also keep in mind the definition from

Spurgeon[5] who distinguishes between managers and individual contributors, which can be used as a definitive decision maker in cases of doubt to which group an engineer belongs.

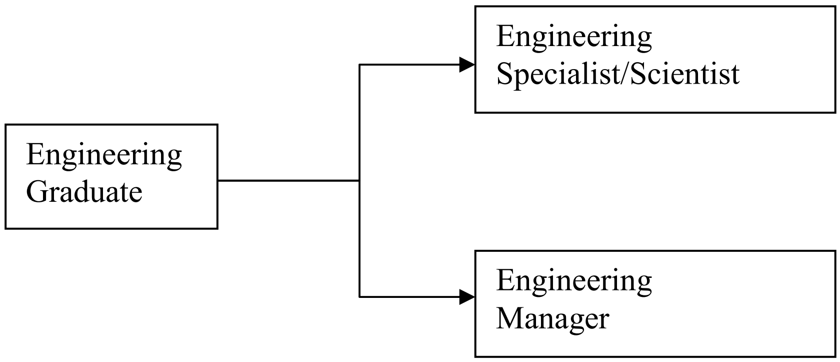

Figure 1: Career path of an engineering graduate

At some point in their career graduates make a choice whether to become a specialist or a manager. We will not focus on why an engineering graduate chooses one career path over the other but will use the fact that engineers do make that choice. We also accept that they might switch affiliations between the two tracks over their career before settling into one of the two.

At this point it is appropriate to define the engineering specialist and the engineering manager more precisely.

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

Similarly an *engineering manager* 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 specialized although they have a broad technical knowledge. They typically have taken up a position of responsibility, such as manager, director, chairman, dean, etcetera.

These definitions do of course leave the door wide open for somebody who will have a hybrid function. We are however, looking at the most predominant activity in order to decide to which of the two types an engineer belongs.

Success definition

Having defined the career track of engineers we now pose the definition of a successful engineer:

> *An engineer is* ***successful*** *if they are respected for their competencies by their superiors, their peers and their employees.*

This paper does not aim to discuss in detail how this 'respect' is going to be quantified. In the next phase of the research the amount of respect an engineer receives for their competencies will be measured in terms of salary, salary with respect to age, salary with respect to number of years of work experience and salary with respect to job responsibility and age as was done in a similar research in the United States by Klus and Jones[13].

In this paper it is addressed what these competencies are which engineers must possess to be successful. It is expected that the competencies, or how they manifest themselves, might differ depending on whether the engineering graduate is an engineering specialist or an engineering manager. In the next paragraph it is suggested what relevant competencies a successful engineer should have mastered. Knowing what these competencies are will allow universities to evaluate their program to see whether their programs give room to mastering those competencies.

Required competencies & skills

So which competencies and skills must an engineer have mastered to be able to attain professional success? Based on a literature survey[2-12] the following list of competencies has been compiled which it is felt an engineer must have mastered in order to attain success. It is expected that these competencies, which are listed in table 1, are to be more or less applicable for both career tracks, but will manifest themselves in different ways.

Competencies	
C.1.	Ability to synthesize
C.2.	Analytical skills
C.3.	Problem solving skills
C.4.	Managerial skills
C.5.	Written communication skills
C.6.	Oral communication skills
C.7.	Net worker
C.8.	Have broad technical knowledge
C.9.	Have specialist technical knowledge

Table 1: The required competencies and skills of a successful engineer.

Validation

Most of the literature in which these competencies were listed is of American origin and the question was raised whether this list would also apply in the European (more specifically Dutch) working culture. To validate the use of this list, it was put to a panel consisting of people working within the aerospace industry in the Netherlands as well as people working at universities & research institutions who regularly employ aerospace graduates from Delft University of Technology. As this research is aimed at aerospace engineering graduates only the list of companies was deliberately limited to institutions with a specific aerospace department.

After having been explained the purpose of the questionnaire as well the distinction made between the two different types of engineers, the employers were asked to indicate for each group of engineers how relevant they deem every competency. This was done on a 5-point scale. Next to that they were also asked if they felt any competencies were missing and how they would rate those missing competencies for each type of engineer.

The panel consisted of 19 people of whom 11 worked in government-funded institutions and 8 in industry. A total of 7 different companies and institutions were represented. Of the panel 9 deemed themselves to be specialists and 10 deemed themselves managers.

The panel was asked to rate the importance of each competency on a five-point scale with 1 being totally unimportant and 5 being very important. The average rating for each of the two types of engineers is displayed in table 2:

Competencies		**Specialist**	**Manager**
C.1.	Ability to synthesize	4.05	4.58
C.2.	Analytical skills	4.84	4.26
C.3.	Problem solving skills	4.63	4.32
C.4.	Managerial skills	3.05	4.84
C.5.	Written communication skills	4.68	4.32
C.6.	Oral communication skills	4.16	4.89
C.7.	Net worker	3.58	4.47
C.8.	Have broad technical knowledge	3.79	4.26
C.9.	Have specialist technical knowledge	5.00	2.72

Table 2 The average rating of competencies for engineering managers and engineering specialists by the expert panel (1 = totally unimportant – 5 very important)

In order to check the reliability of this survey a Student two sample t-test was carried out to see if results for each competency for the manager and the specialist differ significantly. It was found that the competency "Problem solving skills" does not differ significantly between the two types of engineers, all other competencies do. The level of significance of the test was 5%.

From this it seems to go without saying that, except for one, all of the competencies were found to be important competencies for engineers. Regardless whether they are on the specialist career track or on the managerial career track. The one competency deemed not important for the managerial engineer is specialist technical knowledge. As was expected managerial skills are still a necessity for engineering specialists even though the expert panel rates it as a competency that is not very important for specialists.

When asked the question if the expert panel felt there were any competencies missing, a total of 38 competencies were named, some the same. The panel was also asked to score those competencies for their importance for managers and specialist respectively. The competencies were grouped and the most frequently mentioned competencies are listed in the table below:

Additional competencies	Specialist	Manager
A. Ability to change (x2)	4.5	5.0
B. Ability to work in teams (x6)	3.7	4.3
C. Social skills (x5)	3.3	4.6
D. Planning and Organizing/Systematic Planning (x2)	4.0	4.0
E. Continuous education (x2)	5.0	4.5

Table 3: Most suggested additional competencies by the expert panel and their importance to engineering managers and engineering specialists (1 = totally unimportant – 5 very important)

Of the other additional competencies & skills mentioned sometimes character traits were listed and not competencies, such as modesty, and creativity. These although undoubtedly important for anyone to have a successful career these are not skills and abilities which can be acquired and thus used as objective measures and they will therefore not be considered. Other competencies mentioned are embedded in the competencies listed in the original list. An example of that is that part of oral presenting skills should be the ability to present a paper, similarly negotiating skills are part of management skills and abstraction skills lie closely to analytical skills. All depends on the exact definition one uses.

From the feedback given two competencies were added to the original list: the ability for life-long learning and the ability to work in teams.

The ability of life-long learning

The ability for life-long learning was not included in the initial list. The employers in literature mentioned the ability as desirable by the likes of Koen and Kohli[6] and McMasters[7,8,9] but Landis[2] showed in his research that most working engineers are not interested in life-long learning. Hence it was left out. It will be interesting to see if attitudes have changed since the 60s in the next step of the survey.

The ability to work in teams

This ability was not mentioned in the earlier articles from the 60s and 70s by researchers into success but was found to be important by the employers[6,7,8,9,10,11] particularly in the last decade. It is probably a sign of changing times where company structures have changed from a highly hierarchical structure with clear "control and command"-structure to one in which multi-disciplinary teams are operating under a team leader. This ability was probably not as important then as it is now. Both competencies will be incorporated in the new table.

The expert panel was also given the opportunity to add their own views and comments to the questionnaire. A total of nine persons did so. Three of those suggested that the term management competencies was too vague and should really be elaborated upon. Summarizing it was suggested that management skills should be divided into 2 parts to avoid it becoming an empty "buzz"- word:

- People management skills (coaching, performing of performance reviews, negotiating)
- Operational management skills (decision making, financial responsibilities)

Although it was suggested to use the term organizational skills, it was felt that organizational skills would not quite reflect the business (financial responsibility, decision making) side of the intended competencies. Therefore it has been changed to operational skills. Another suggestion was to keep negotiating as a separate skill but as negotiating is really about persuading someone it was felt this was in fact a people management skill.

A further, often mentioned, comment was that there was a middle group between the manager and the specialist the multifunctional engineer, or the systems engineer. For the purpose of this research this engineer would be classed as a specialist with as its specialism: multi-disciplinarity or systems design. Finally it was rightly pointed out that the different competencies manifest themselves differently. This will be taken into account in the next part of this research.

Conclusions & further research

Based on literature and the comments and suggestions from the expert panel the following list of competencies and skills an engineer must master if they are to be successful was compiled.

Competencies	
C.1.	Ability to synthesize
C.2.	Analytical skills
C.3.	Problem solving skills
C.4.	People management skills
C.5.	Operational management skills
C.6.	Written communication skills
C.7.	Oral communication skills
C.8.	Net worker
C.9.	Have broad technical knowledge
C.10.	Have specialist technical knowledge
C.11.	Ability for life-long learning
C.12.	Ability to work in teams

Table 4: The required skills and competencies indicative of the successful engineer

This research has confirmed earlier findings in the United States and shows that, despite the completely different company cultures between the United States and the Netherlands, employers value similar competencies.

This list will now be used as the starting point for the next phase of the research. In this phase all alumni of the faculty of aerospace engineering will be approached with a questionnaire asking them to answer questions on their activities on the job for each competence or skill as well as other information such as job responsibility level, salary and information and feedback on their time studying in Delft.

The results of this survey should yield a description of the aerospace engineering alumni population in the Netherlands, which is currently lacking, and give the faculty an idea of how successful its alumni really are. At the same time the results will allow us to select a new, smaller research population who will be interviewed in more detail about their educational experience at Delft University of Technology and its relevance on their career as well as any discrepancies in their educational experience. A graphical summary of the research set-up is given in figure 2.

Appendix A: Faculty of Aerospace Engineering at Delft University of Technology

The degree of Aerospace Engineering[16] at Delft University of Technology[15] exists since 1940 and Aerospace Engineering has been an independent faculty since 1975. It currently has some 1700 students enrolled in their Bachelor and Masters programs. Students graduate with a Bachelors of Science degree in Aerospace Engineering, which is internationally recognized (ABET) and many continue on to obtain a Master of Science degree in Aerospace Engineering at the same Faculty.

Appendix B: Acknowledgements

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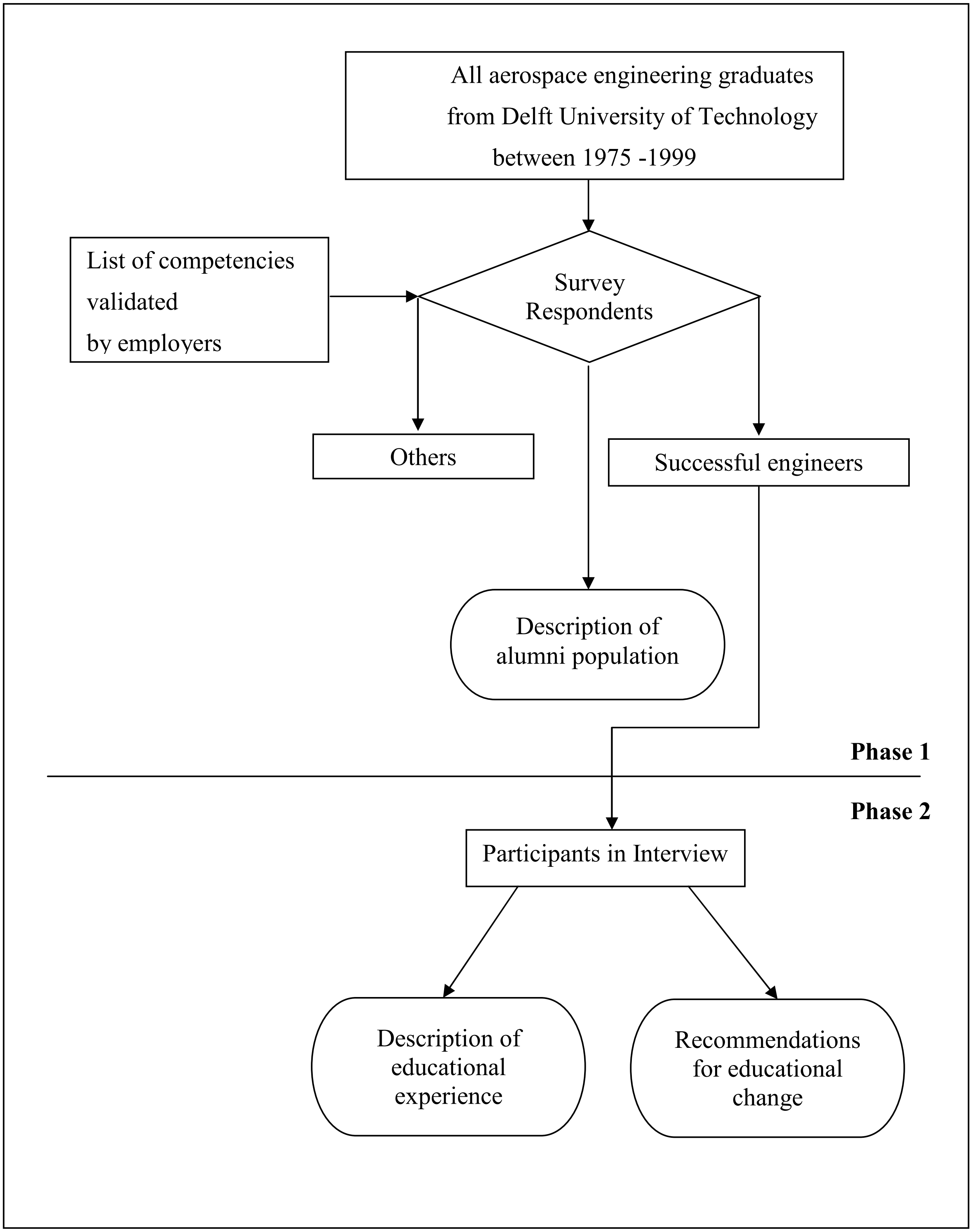

Figure 2 Overview of research set-up

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