Comparison of Career Success Competencies and Engineering Leadership Capabilities

Robyn Paul and Dr. Lynne Cowe Falls
Schulich School of Engineering, University of Calgary
rmpaul@ucalgary.ca

Abstract *– Societal expectations of twenty-first century engineers have dramatically changed over the past few decades. There is a need to educate engineers not just in technical subjects, but also in many non-technical areas including globalization, communication, and leadership. There has been a growth of engineering leadership education programs offered by postsecondary engineering institutions. The effectiveness of these programs is often measured by the student's acquisition of skills, without considering the benefit of these skills on the students' careers. Using the career success competencies model, this paper seeks to determine if engineering leadership education impacts career success. The analysis showed a high amount of correlation with engineering leadership capabilities, indicating a positive relationship between engineering leadership education and career success. The most significant competencies related to an engineer's career success were career insight, proactive personality, openness to experience, and lifelong learning.*

Keywords: Engineering Leadership, Boudaryless Career, Career Success, Engineering Leadership Education

1. INTRODUCTION

Worldwide national regulatory bodies mandate the set of attributes that students graduating from engineering institutions will have achieved. These attributes have been deemed the skills required for engineers to succeed in today's society, including both the essential technical knowledge and skills, as well as the nontechnical skills, attitudes and character traits.

Over the last decade or so, there has been an increased interest in developing and researching these professional skills in engineering students. Leadership education has had a particularly high rate of growth and development in post-secondary engineering institutions. A 2009 summary [15] of engineering leadership education found that the majority of the 70 programs reviewed were less than 5 years old.

To measure the success of engineering leadership teaching and learning activities, students are often assessed before and after to determine if they have gained the essential leadership skills [1], [10]. If the skills are gained, the activities are considered successful in producing a more proficient engineer with leadership capabilities. One key element missing in this assessment process is the measurement of whether or not possessing leadership skills is beneficial to an engineer's career. In order to be able to determine the relationship between engineering leadership capabilities and career success, first there must be a clear method of how to measure career success in engineering.

General career success measurement instruments have been researched and developed for decades [33], and a widely accepted model of career success will be discussed. The career success competencies in this model will then be used as a point of comparison against engineering leadership capabilities. Thus, the goal of this paper is to determine if there is a relationship between career success competencies and engineering leadership capabilities.

2. CAREER SUCCESS COMPETENCES

2.1 Boundaryless Career

At the end of the 20th century, it was apparent that employees were no longer restricted to a single organization throughout their career. Traditional assumptions about employment had changed, and people were able to obtain sequences of experiences across both organizations and employers [22].

The term boundaryless career was introduced in 1993 at the Academy of Management Meeting in Atlanta, Georgia [4]. Boundaryless careers are simply defined as "sequences of job opportunities that go beyond the boundaries of single employment settings" [9]. Hierarchical relationships are broken down, and there is

increased ability to move across occupational careers and employers [4].

2.2 Measurement of Career Success

There are two types of career success. Objective career success includes extrinsic measures such as salary, upward mobility, and managerial level [22]. Subjective career success includes intrinsic measures, where individuals are able to evaluate their own career success through "self-defined aspirations, values, needs, standards and career stages" [31].

Traditionally, career success was associated with extrinsic measures such as increased salary and upwards progression within an organizational hierarchy. However, boundaryless careers often have lateral movement within organizations, and can be viewed as more disorganized and unpredictable [31]. These extrinsic measures of career success, are therefore no longer valid measurements.

Subjective career success represents a judgement on career accomplishments and a sense of progress towards career goals [22]. Thus, intrinsic measures are much more suitable to the modern boudaryless career. Common examples of intrinsic measures include career satisfaction surveys [16], career commitment [17], wage satisfaction [22], and marketability [11].

2.3 Career Competencies Model

Three career competencies have been identified as requirements to be able to cope with the complexity and change of a boundaryless career: knowing-why, knowing-whom and knowing-how [9], [7]. Eby, Butts, and Lockwood used these three competencies as the basis for developing a model to measure career success [11]. At least two intrinsic variables for career success were associated with each career competency, as summarized in the model shown in Fig. 1.

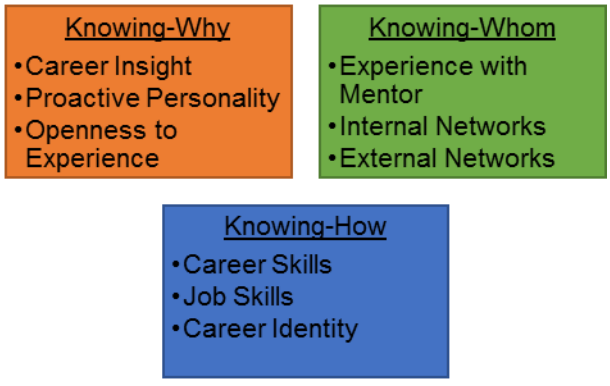

Figure 1. Model of three career competencies and the related variables of success [11].

The knowing-why competency focuses on the individual's career motivation, personal meaning and identification [9]. It considers the individual's willingness to explore different possibilities, and ability to adapt to change in one's work environment [11]. This competency is associated with awareness of one's needs, abilities, interests, and aspirations related to work-experiences, as well as one's self-concept and self-identity [7].

Knowing-whom refers to an individual's career-related connections, both within and outside the organization. It is characterized not only by development of relationships, but also in how these relationships are utilized [7]. An extensive network is beneficial to the individual as a resource, a new source of learning, and an attained reputation [9].

The final career competency, knowing-how, emphasizes an individual's broad and flexible knowledge, the portfolio of career skills and job skills that are useful across organizational boundaries. Career identify is an apt measure of skill development and continuous learning [11].

Table 1 provides a summary of the instruments used to measure each variable in the proposed model. Many of these instruments were developed by others and were reduced in length for this model. The original source of each instrument and the number of items used for this model is seen in Table 1.

Table 1. Summary of instruments used by Eby et. al. [11] to measure variables of career success.

Career Success (CS) Variable	Original Source (as cited in [9])	No. of Items
CS1. Knowing-Why		
- Career Insight	[19]	3
- Proactive Personality	[5]	10
- Openness to Experience	[27]	8
CS2. Knowing-Who		
- Mentorship	[11]	1
- Internal Networks	[11]	3
- External Networks	[11]	4
CS3. Knowing-How		
- Career / Job Skills	[11]	5
- Career Identity	[21]	4
Perception of Career Success	[16]	5

3. ENGINEERING CAREER SUCCESS

An individual's occupational context impacts their perspective of the relative importance of the different career satisfaction elements. Also, people from diverse occupational backgrounds will interpret the measures of career success differently [29]. It is therefore important to consider career success within an engineering context. Although limited literature exists in the field of measuring engineering career success, factors determined to be essential to engineering career success will be discussed.

Lifelong learning is a fundamental necessity for success in the 21st century engineering career [26]. Staying abreast with the most recent technological advancements is essential for being innovative and creative. Lifelong learning is included in the variable "career identity" in the career competency model.

A study in the engineering construction industry found the most critical aspect to fostering a successful career path was developing a professional network [6]. This includes networking, mentorship, training, and constructive feedback. The knowing-whom competency incorporates this, however the relative importance of this competency may be higher in an engineering context.

The same study found young engineers were aware that they were responsible for their own personal career development and self-improvement [6]. Further studies have shown students desire to participate in their learning process and to be proactive players in improving their learning [24]. This aspect of engineering career success relates to the model's "proactive personality" variable.

There is a dearth of literature on measurement of career success in an engineering context. However, based on the limited resources, the career competency model recommended in Fig. 1 is appropriate and can be used for measuring engineering career success. Although the importance of each of the variables may differ, the overall instrument can be applied to an engineering context.

4. ENGINEERING LEADERSHIP CAPABILITIES

Engineering leadership has been highlighted as an important skill for engineers to be able to succeed in their 21st century careers by many, including ABET [28], the National Academy of Engineering [20] and CDIO [8].

The Gordon-MIT Leadership Program (GLP) was launched in 2007 and aims to develop the next generation of technical leaders [12]. Based off an MIT Sloan School of Management leadership model [3], GLP customized an engineering leadership model, which has since been developed and improved [14]. The GLP model was also used as a point of reference for the new addition to the CDIO syllabus, *Leading Engineering Endeavors* [8].

Table 2. Summary of capabilities of effective engineering leaders determined by [14].

Engineering Leadership (EL) Capability	Description
EL1. Attitudes of Leadership	Reflection on beliefs and attitudes; sense of responsibility; foundational leadership skills
EL2. Relating	Develop key relationships; listen to others; understand diverse viewpoints; advocate for your position
EL3. Making Sense of Context	Understand the context of leadership; comprehend and explain complex environment simply to others
EL4. Visioning	Create purposeful images of the future; identify what could and should be
EL5. Delivering on the Vision	Move from abstraction to innovation, invention, and implementation
EL6. Technical Knowledge and Reasoning	Deep working knowledge of discipline; understand, decompose, and recombine elements of technical problems

The GLP model contains six central capabilities of effective engineering leaders. The full list of individual skills is shown later in Figure 2, or can be found on the GLP program website [12]. This model will be used as the comparison for the analysis, and a summary of the model is provided in Table 2.

5. MAPPING CAREER SUCCESS COMPETENCIES TO ENGINEERING LEADERSHIP CAPABILITIES

An understanding of the potential impact of engineering leadership education on career success can be determined by a comparison of the career competency model (Table 1) and the engineering leadership capabilities (Table 2).

It is important to note that leadership skills are beneficial to all engineers, regardless if they plan to pursue leadership roles. Professional skills such as communication, time management and self-reflection are valuable across every engineering discipline. All engineers must be prepared to work in a team environment when solving technical problems [23].

The individual engineering leadership capabilities are important for being an effective engineering leader, however not every single skill may be required for a successful career. Therefore, the analysis seeks to map the career success competencies (Table 1) to the capabilities of effective engineering leaders (Table 2).

Each career competency variable definition was compared with the individual leadership capabilities to determine if there was a correlation. Correlations were classified as "Strong", "Medium", or "Weak". A strong correlation showed a high level of similarity, often with

synonymous words and phrases being used. Medium correlations had similar concepts that were being applied in a different context. A weak correlation showed little similarity in the meaning, even though the broad topic may have been the same.

A summary of the correlations is shown in Fig. 2, and the remainder of this section details the reasoning for each correlation and classification of strength.

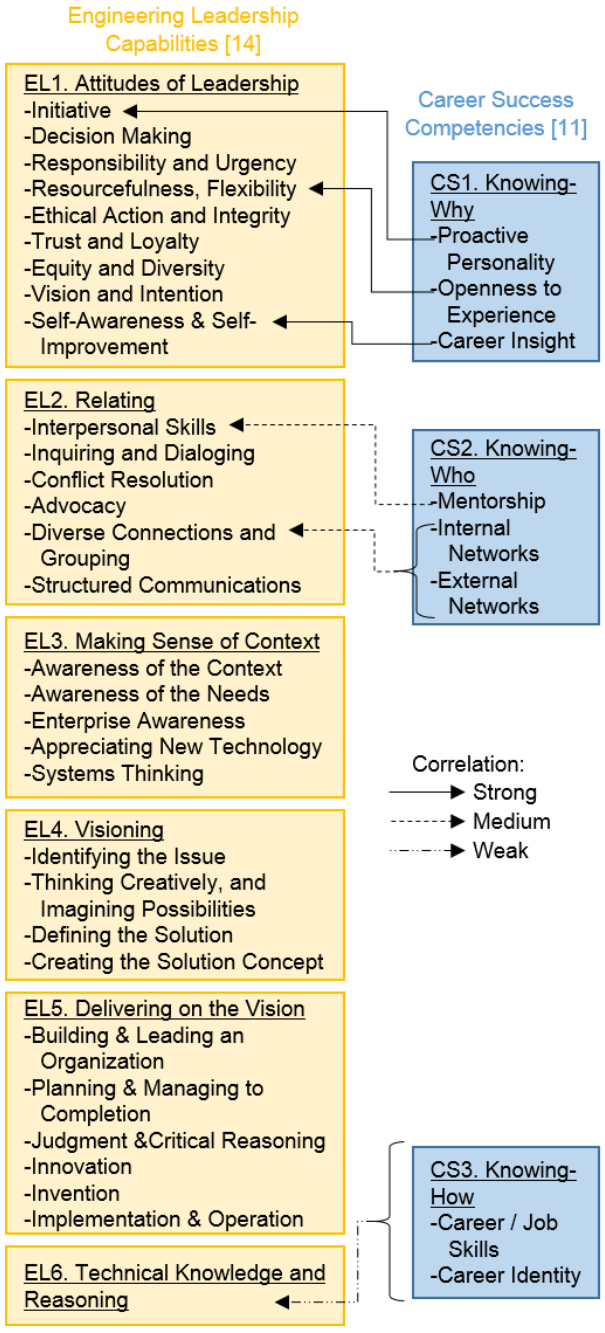

Figure 2. Correlation between career success competencies and engineering leadership capabilities.

5.1 Knowing-Why (CS1)

The three variables associated with knowing-why were career insight, proactive personality and openness to experience. Each of these had a high correlation to skills in EL1, "attitudes of leadership".

5.1.1 Career Insight. Career insight was defined as having realistic career expectations, and an understanding of one's strengths and weaknesses [11]. An individual skill included in EL1 is "self-awareness and self-improvement". This includes awareness of one's own personal, interpersonal, and professional skills [14], highly correlating with the definition provided previously of career insight.

5.1.2 Proactive Personality. The tendencies to identify opportunities, to take action, to demonstrate initiative and to persevere are elements of a proactive personality. An individual skill listed in EL1 is "initiative". This skill is described as the willingness to create a vision and take action, and teaching students the importance of being proactive, which highly correlates with a proactive personality.

5.1.3 Openness to Experience. This is defined as individuals who are "imaginative, curious, broadminded and active" [11]. In EL1, the skill "resourcefulness, flexibility and change" includes the ability to be adaptable, and willingness to take alternative courses of action. Both of these skill definitions show an openness to experience and have a strong correlation.

5.2 Knowing-Who (CS2)

The three variables associated with knowing-who were mentorship, internal networks and external networks. These variables each had a medium correlation to skills in EL2, "relating".

5.2.1 Mentorship. Developing a mentoring relationship was described in CL2 as important for developmental experiences, visibility and exposure, as well as a valuable source of learning [11]. One of the individual skills in EL2 is "interpersonal skills", which includes "coaching and teaching, and providing and receiving evaluation and feedback" [14]. A medium level of correlation was given as mentorship is not directly mentioned, however similar elements are emphasized as those in the provided career competency definition.

5.2.2 Internal and External Networks. These two CS2 variables were defined as individuals being well connected for support and development within their

company, as well as outside of the company. They do not map to separate skills of EL2, but rather to one individual skill called "Diverse Connections and Grouping". This skill emphasizes connecting with diverse groups of people who have different backgrounds, skills and experiences to "help achieve the goals and technical solutions" [14]. The slightly different meaning of the two definitions give them a medium level of correlation.

5.3 Knowing-How (CS3)

The two variables associated with knowing-how were career / job skills and career identity. This career success competency had the weakest correlation to engineering leadership capabilities, however it related to skills mostly within EL6, "technical knowledge and reasoning".

5.3.1 Career Skills. The emphasis of this competency is on the transferability and flexibility of one's career skills, rather than just the career-related skills themselves. EL6 only discusses the importance of discipline specific technical engineering skills, without mentioning that the skills should be portable. However, EL5 discusses the need for leaders to be able to manage change, which could be interpreted indirectly as a need for flexible skills. Although these engineering leadership skills have some similarity, the correlation is weak.

5.3.2 Career Identity. Career identity also has a slight link to EL6, "technical knowledge and reasoning", however career identity was defined as continuous improvement and opportunity development. Continuous improvement is mentioned in the leadership capability EL1, where it discusses proactive planning for continuing education and future careers. Opportunity development is included in EL5, "develop approaches to incorporating competence outside of one's enterprise" [14]. Overall, only a weak correlation is observed.

6. DISCUSSIONS

All of the career competencies map to engineering leadership capabilities, with varied levels of correlation strength. The career competency with the highest correlation strength was knowing-why, which correlated strongly to EL1, "attitudes of leadership". It has been shown that knowing-why is the greatest predictor of career success [7]. Therefore, if engineering leadership education programs are able to foster "attitudes of leadership" in their students, this is a good indication that there would be an improved level of career success.

Knowing-how is the second most important career competency on impacting career success [7]. Lifelong learning, a skill related to knowing-how, was also emphasized in the career success literature as a critically important skill for engineers [26]. However, knowing-how was the competency with the lowest correlation to engineering leadership capabilities. Career identity and lifelong learning may be understood as a career skills expected to be taught outside the context of engineering leadership education. However, to improve the success of graduating engineering leaders, it would be beneficial to add this skill in leadership programs.

A quick review of the CDIO Syllabus for "Leading Engineering Endeavours" [8] and the National Academy of Engineering definitions of leadership [20] showed that lifelong learning was also not included in these documents. Although lifelong learning may not be a skill required to become an effective engineering leader, it is a skill that is essential for all engineers to succeed in the fast paced technological innovation of the 21st century [26]. Engineering students, particularly those interested in leadership activities, should be aware of its importance.

Although the common maxim, "it's not what you know, it's who you know" can be true [32], the knowing-who competency has been shown to have little impact on career success [7], [30]. This contradiction could be due to the type of networking, as supervisor-focused networking (i.e. championing) can increase career success, whereas self-promotion has been shown to decrease career success [13]. The type of career success being measured (objective vs. subjective) may also effect the determined impact of networking. Regardless, networking, mentorship and building relationships is important for students for many reasons other than career success (e.g. visibility, exposure, improved learning experiences, and guidance) and should continue to be a part of engineering leadership education programs.

An understanding of the importance of the different elements of leadership that impact success in the engineering industry would be beneficial. One study showed that socio-emotional intelligence had the strongest correlation to successful leadership compared to personality and mathematical-logical intelligence [18]. This included verbal expression through assertion, emotive availability, and inspiration. It is notable that again, this emphasizes the importance of knowing-why (emotional intelligence), over knowing-who (personality) and knowing-how (math-logic intelligence).

It is also important to consider is how engineers perceive themselves as leaders. As stated by Rottman, Sacks and Reeve, "engineering leadership depends on engineers recognizing themselves as leaders" [25]. One of the largest barriers to engineering leadership at postsecondary institutions is that leadership activities supported by engineering faculties are primarily through optional extracurricular involvement [2]. Students may view these experiences as exterior to their essential learning experiences, and thus decide not to participate.

However, the results from this study show that participation in engineering leadership education programs could improve a student's career success.

7. CONCLUSION

All the career success competencies correlated to an engineering capabilities, and there were skills that had a strong correlation with the knowing-why competency. This indicates that teaching engineering students skills in leadership would have a positive impact on their career success. These results are valuable to all engineering students, not just those who plan to pursue a career path in leadership.

7.1 Future Work

The model recommended in this paper could be used as a measure for career success for postsecondary engineering institutions doing curricular development. Using the model would allow institutions to understand the impact their efforts are having on students' career success.

A similar analysis of the career competency model to the graduate attributes provided by national accreditation bodies, such as ABET or CEAB, may provide insight to the areas of development that enhance career success.

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