Perspectives of Global Engineering Leadership from Worldwide Faculty and Students

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Abstract— **Proficient leadership skills are increasingly crucial for engineers as they are expected to work in multi-disciplinary and multicultural teams across the world. However, perspectives of engineering leadership are ill-defined and may vary depending on the region, school or country of residence or work. While both industry and academia concur that leadership skills are crucial to engineering graduates, there is considerable controversy over the definition of 'global engineering leadership'. This lack of consensus may hinder the future formation of globally-prepared engineering leaders.**

This work-in-progress paper describes an exploratory study to understand how 'global engineering leadership' is perceived by engineering students and faculty across worldwide institutions (predominantly across African, European, North and South American countries). The study utilizes a semi-structured survey developed from literature on national and international engineering leadership and prior work on engineering professional identity. Data was collected from two populations, the first representing students registered in engineering across worldwide institutions and the second representing engineering faculty who have demonstrated interest in leadership at their institutions. The two populations will allow scholars to compare and contrast how these perspectives changed across the different groups with the goal of developing a working definition of 'global engineering leadership'. This definition may serve as a starting point to develop recommendations and strategies for engineering educators wishing to introduce their students a globalized view of engineering leadership.

Keywords—Global, Engineering, Leadership, Faculty, Students

I. Introduction

There is considerable discrepancy in engineering education over the required competencies that engineering graduates should possess [1]-[5]. The common understanding in the last decade is that engineering graduates must be better prepared for areas outside of the technical domain. This is particularly relevant on a global scale in relation to leadership, which can vary depending on industrial and societal needs.

Leadership in engineering can be defined in variety of ways and may have a different meaning depending on the audience and context [6]-[8]. While industry and academia agree that leadership skills are critical for engineering graduates, no consensus exists regarding the definition of 'engineering leadership', let alone 'global engineering leadership'. A better understanding of these terms will help institutions develop and improve engineering leadership education based upon a commonly agreed upon definition. Therefore, there is a need to investigate the elements defining these terms as perceived by both engineering students and faculty across worldwide institutions.

A. Leadership in Context

Modern societies, with increasingly converging knowledge and global economies, and additional factors such as the increase of global mobility and competition, require engineers to expand their horizons and be ready to work effectively within inter-disciplinary and multi-cultural groups to eventually become leaders of such teams [9]. A slightly different, although related reason is based on the general concept of engineering professional service, which requires engineers to take a leadership role in the development of society and as part of their professional responsibility. Although still in the framework of engineering education, there is likely differences between the role of engineers in different regions and countries. For example, in the African context, engineering leaders normally have to work in the state of permanent crisis – with an awareness of possible dangers while recognizing the range of opportunities [10]. These leaders foster adoptive leadership practices amongst peers to develop sustainable strategies for continued growth in their society.

Leadership can be defined as 'the process of interactive influence that occurs when, in a given context, some people accept someone as their leader to achieve common goals' [11, p. 3]. This definition describes the actual meaning of the term in a scientific or technical context. However, there have been numerous attempts to give more a precise definition because 'there are almost as many definitions of leadership as there are persons who have attempted to define the concept' [11, p. 7].

Leadership has been traditionally defined in terms of behavior, process, ability, influence, and occupation. The general consensus, however, indicates that leadership entails a process of intentional influence over other people, or group of people, to effectively facilitate certain activities.

Collectively considering these traits, leadership is categorized between attitudes (such as those based on culture, mindset, and approach), style (patterns of behavior or engaged activities), and skills (ability or expertise to lead). A summary of these elements is presented in Fig. 1.

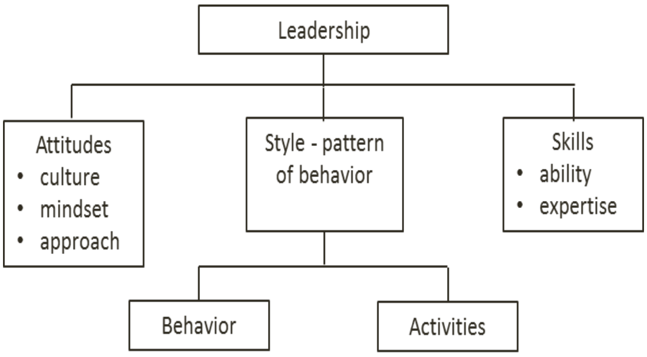

Fig. 1. Proposed hierarchical elements of leadership as summarized in a review paper from Schuhmann [12].

These traits as interpreted from literature for the use of this study are further described below:

- *Attitudes* – consists of culture mindset and approach and can be attained by continually learning. This characteristic can be attained by continually learning and may be manifested by a service orientation, positive energy, and a deep belief and trust in other people. These attitudes are are balanced throughout leadership contexts [13].
- *Style* – leaders may demonstrate certain patterns of behaviors such as interpersonal interaction, empathy and openness to subordinates, while at the same time participating in activities such as setting expectations, providing guidance, promoting ideas and identifying resources needed to propel ideas forward [12].
- *Skills* –involve the ability and expertise of a leader as they relate to organization commitments and management, team and conflict management, and interpersonal management and motivation.

B. Engineering Leadership in Curriculua

According to the National Society of Professional Engineers [14], within an engineering context: 'leadership incorporates a number of capabilities which are critical in order to function at a professional level' [14, p.1]. Therefore, the NSPE defines leadership through the list of required capabilities:

1) *The ability to assess risk and take initiative*
2) *The willingness to make decisions in the face of uncertainty*
3) *A sense of urgency and the will to deliver on time in the face of constraints or obstacles*
4) *Resourcefulness and flexibility*
5) *Trust and loyalty in a team setting*
6) *The ability to relate to others*

In response to this call, educational institutions have implemented engineering leadership education in several ways including a variety of programs and methods of delivery. Examples of programs within engineering include: special, separate programs (both at undergraduate and graduate level), single courses, and extra-curricular activities. Moreover, within engineering courses, specified pedagogical approaches have been considered to teach leadership to students such as problem-based learning, mentoring, interdisciplinary and/or intercultural team projects, industry-sponsored and industry-paid projects and institutional cooperation. It is worth mentioning that many of these aforementioned efforts are occurring predominately in the USA [15, 16], Europe and Australia [15].

For other countries, engineering leadership education is largely tied to professional partnerships with industry through mentoring, internships, and networking opportunities. In that context, students learn elements of engineering practices while acquiring transferable skills relevant to the context and culture of that particular country. Due to the contrast in approaches and context, it is important to understand how engineering faculty and students define engineering leadership and global engineering leadership to recognize the differences and similarities. This can inform more globalized approaches to engineering leadership education in the future.

II. Methodology

Since professional competencies such as leadership are ill-defined within engineering and can be variable depending on multiple industrial and societal needs, this early investigation seeks to understand how engineering students and engineering faculty perceive 'global engineering leadership'. As such this study seeks to explore the following research question:

Research Question:

In what ways do the terms 'engineering leadership' and 'global engineering leadership' definitions vary between engineering faculty and students in different countries?

A. Reseach Design

The study utilized a semi-structured survey that was developed based on literature and reports of engineering leadership from national and international engineering audience. Further, the study built upon a previously established survey to explore engineering professional identity created by Villanueva and Nadelson [17]. The survey included 16 demographic questions which helped to identify participants current role (student, graduate student, faculty or administrative), engineering field/discipline, age and years of experience, country of residence, languages, ethnicity and gender. Beyond collection of demographics, the survey centered around exploring participants perspective of engineering and global engineering with open ended response questions including:

- In your own words, define 'engineer'.
- In your own words, define 'leadership'.

- In your own words, define ‘engineering leadership’.
- In your own words, define ‘global engineering leadership’.
- What are the important attributes of engineering leadership?
- What are important behaviors of engineering leaders?
- What are the important skills of engineering leaders?
- What activities would engineering leaders be involved in?
- What attributes are needed to become a ‘global engineering leader’?
- What behaviors are needed to become a ‘global engineering leader’?
- What skills are needed to become a ‘global engineering leader’?

All procedures were approved for human subjects research by the Institutional Review Board office at Utah State University.

B. Population Demographics

To date, a total of 38 respondents completed the survey (21 from engineering faculty and 17 from undergraduate engineering students). All respondents were from institutions of higher education in Republic of South Africa, Botswana, Poland, France, and the United States.

1) Students

Of the total student respondents, 12 students identified as male, 4 as female, and one respondent did not indicate a gender. The majority of student respondents were in the first or second year (47%) and their primary field was mechatronics engineering (41%) (Figures 2 & 3). The majority of respondents were citizens of the Republic of South Africa (64%) and spoke English (94%) and Afrikaans (58%). Most students identified as White (53%) followed by Black or African (23%).

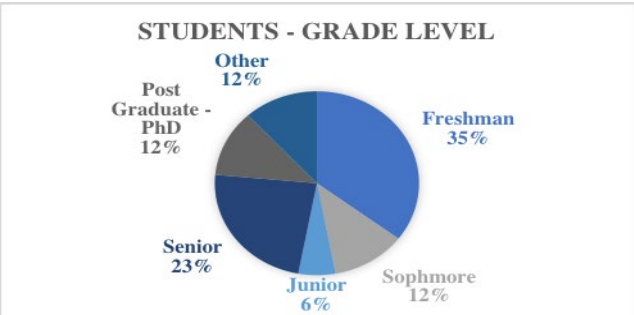

Fig. 2. Student Particpants Grade Level

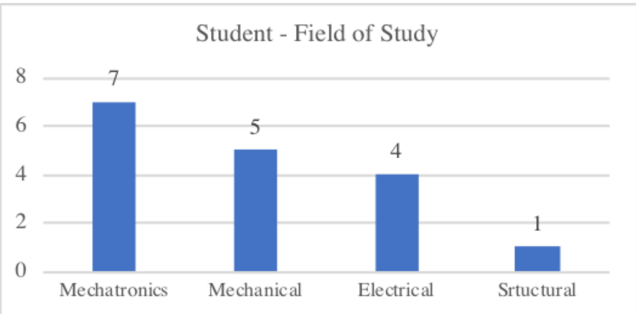

Fig. 3. Student Participant’s Field of Study

2) Faculty Demographics

Twenty-one faculty responded to the survey. Of the respondents, 19 identified as male, 1 identified as female, and one responded did not indicate a gender. The majority of instructors held a Ph.D. (85%) and taught undergraduate courses (59%). The sample of faculty showed greater diversity in fields of study and nationality, which are show in Figure 4 & 5. Similar to the student population, the majority of faculty responded identified as White (52%) followed by Black or African (19%).

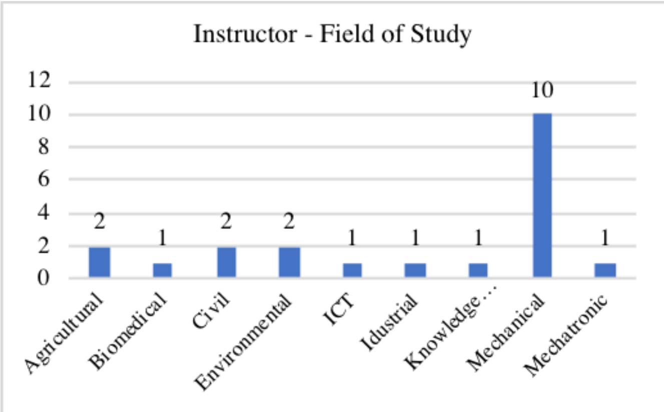

Fig. 4. Faculty Participant’s Field of Study

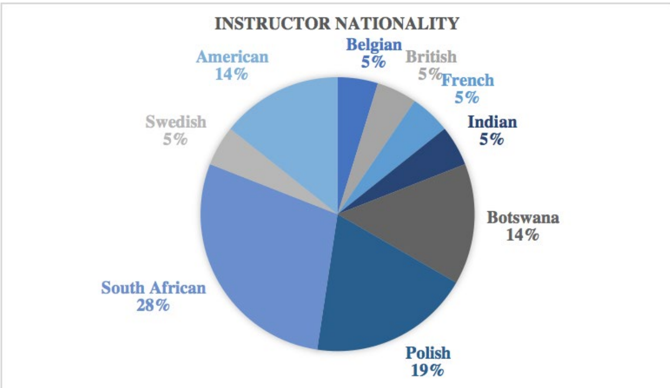

Fig. 5. Faculty Nationality

III. RESULTS

Thematic analysis of the participants responses when describing ‘*engineering leadership’* and ‘*global engineering leadership’* can be grouped into four main themes which correlate with the leadership attributes previously identified by Schuhmann [12]. These themes of expertise (skill), mindset (attitude), behavior (style) and context allow to build on the model of leadership described in Figure 1. A description of each theme is explained below:

- **Expertise (Skill)** - Consists of a background knowledge in a technical field (e.g. engineering). These sources of knowledge can be specific or process-oriented. For engineering and global leaders, expertise also involved a background knowledge of management, organizations, budget, resources, design, communication, and interpersonal skills.

- **Mindset (Attitude)** - This is an expansion of background knowledge and expertise in that it reflects an individual's cognitive inclination toward performing an action. Examples of these would be a leader that uses a logical, rational, analytical, innovative, forward-thinking, or holistic approach to solve a problem. Within mindsets, a leader that uses these cognitive approaches can help others reach a common goal.
- **Behavior (Style)** - This construct was built upon the prior categorization of leaders (in Fig. 1) but relates to more of the actionable outcomes of a leader. For example, a leader that provides guidance, motivation, advocates for, influences, drives a project forward, makes project decisions, contributes to common goals, and mentors others are considered to put in place the actions that can yield an outcome.
- **Context** - This construct was primary discovered as we coded for differences between 'engineering leadership' and 'global engineering leadership'. Leaders may respond differently to a problem or project based on their role for societal impact, the context of their disciplinary expertise, and the scale of the context of the problem (e.g. global scale, international scale, regional scale).

Among faculty and students, coding of these four themes varied. For faculty, when discussing '*engineering leadership*', the majority of the respondents emphasized the importance of technical expertise and the behavior of guiding others as key elements in their leadership that was based on their engineering training and background.

When asking about '*global engineering leadership*', faculty emphasized the need for leaders to consider a process-type expertise and the context of the scale of the problem in their approaches. Among the important attributes of global engineering leaders, a higher emphasis was placed on flexibility and interpersonal skills whereas engineering leaders were described as requiring more management, group-based approaches, and better decision-making and synthesis skills.

For students' definitions of '*engineering leadership*', a major emphasis was placed on technical expertise, the context of the engineering discipline, and the need to contribute as a leader rather than oversee the work of a team. When asking about '*global engineering leadership*', students emphasized the need for leaders to consider technical expertise, the context of the scale of the problem in their approaches, and the type of engineering discipline. Among the attributes of global engineering leaders, a higher emphasis was placed on technical and interpersonal skills, communication, and the scale for the problem. In terms of engineering leadership, students identified that important attributes consisted of open-mindedness, inclusivity, and managerial skills.

Additional emerging characteristics of an engineering leader among both students and faculty were self-confidence, ethics and caring. For global engineering leaders, the groups relied on the importance of cultural awareness, resilience, and honesty. Attitudes were seldom mentioned among the participants. Given the participant responses, we can provide additional insight into the model for engineering leadership and global engineering leadership. Tentative models for an Engineering Leader and Global Engineering Leader are proposed in Figures 6 & 7 based upon participant responses.

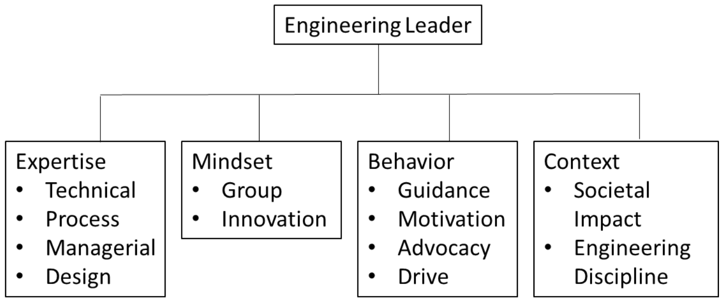

Fig. 6. Elements of Engineering Leadership as Descirbed by Faculty

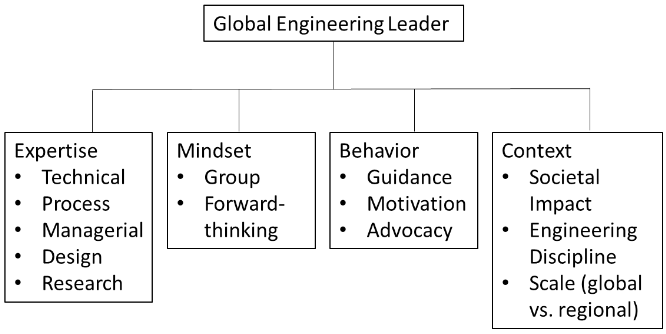

Fig. 7. Elements of Global Engineering Leadership as Described by Faculty

IV. Discussion

Among the participants, engineering leadership and global engineering leadership definitions encompassed the four themes identified with a main difference among the two encompassing the need to consider the context of leadership from an engineering discipline and scale-of-the-problem standpoint. This finding parallels findings from Gabbar et al., which indicate that the country and context of the problem will guide the leadership that will occur among engineers [10].

Engineering leadership definitions varied greatly between engineering students and faculty, where students emphasized more on communication and interpersonal skills and faculty identified management, decision-making, and synthesis as major attributes. This finding may be reflective of the differences between experience and actual leadership positions versus imagined leadership positions. Engineering students in much of the engineering education literature are considered novice engineers as they have not completed their undergraduate curriculum or fulfilled a professional practice experience [18].

While the study did not differentiate among demographic groups or countries of origin, preliminary findings start to suggest that the contextual interpretations of engineering leadership and global engineering leadership varied by country (e.g., South Africa versus Botswana). Further work is underway to specify these contextual differences among the participants.

V. CONCLUSION

While preliminary, the work is beginning to identify the importance that context plays in the definition of global engineering leadership. Some new themes have been also identified that differ from the traditional definitions of leadership and may support the need to better categorize how engineering faculty, students, and those that are in leadership positions represent the expertise, mindsets, behaviors, and contexts explained.

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