Engineering Students' Visual Metaphors for Mentorship: Implications for the Candidacy Period

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Abstract—**Mentorship is important to engineering activity. Yet, little attention is paid to this process within the engineering domain. This paper seeks to remedy this by analyzing the metaphors for mentorship produced by engineering students employed to work as mentors to young adults tasked with training residents in their communities regarding specific digital skills. Metaphors are used because they provide unique insight into the underlying conceptions that individuals hold about a topic or issue. The paper shows not only that metaphors are useful in garnering understanding as to how students conceive of the mentor-mentee relationship, but also that there is scope for using these understandings to provide more focused mentoring during their future candidacy period.**

Keywords—engineering education; mentorship; metaphor analysis; professional registration of engineers; digital ambassadors

I. INTRODUCTION

In South Africa, mentorship plays a particularly important role in the development of professional engineering capacity. Upon completion of undergraduate study, would-be engineers enter into a candidacy period, during which time they are expected to accumulate a wide range of work experience, under the guidance of a professionally registered engineer who acts as a mentor to the candidate. This relationship is thus crucial to the development of young engineering professionals. The aim of this paper is to examine undergraduate students' visual depictions of mentorship so as to understand how they conceive of this relationship. This is done using the technique of metaphor analysis, where individuals' metaphors for a topic or issue are qualitatively analyzed so as to identify those individuals' underlying conceptions about that topic or issue. This paper is structured such that it provides an overview of the relevant literature pertaining to mentorship, and then discusses the methodology employed. Thereafter, the data obtained is discussed and conclusions drawn. First, however, the professional registration process, as enacted within the South African context, is described.

II. MENTORSHIP AND THE PROFESSIONAL REGISTRATION PROCESS IN SOUTH AFRICA

The Engineering Council of South Africa (ECSA) is responsible for the registration and licensure of engineering practitioners who hold relevant, accredited qualifications. As is the case elsewhere in the world, candidate engineers must also accumulate a minimum of three years of practical training and experience before they can be registered. In South Africa, ECSA policy requires that employers sign a Commitment and undertaking (C&U) to provide structured training and development to candidate engineers within their employ. One of the conditions of this C&U is the appointment of a mentor. This mentor can be appointed from within the employing organization, or can be appointed externally. The duties of the mentor include the following, inter alia [1]:

- giving guidance on career planning and professional development;

- advising candidates on training programs that meet requirements;

- ensuring candidate engineers are exposed to required practical training elements;

- facilitating the development of candidates' abilities to think independently;

- encouraging candidates to work as team members;

- ensuring that candidate engineers incorporate quality assurance techniques in their work; and

- receiving progress reports by candidates and appraising them in a critical but constructive manner.

The mentor, therefore, does not fulfil the same role as a supervisor and, whereas the supervisor does not need to be professionally registered with ECSA, the policy requires that all mentors be registered with the Council. The mentor must also provide a letter of reference for the candidate upon application for registration with the Council.

It is thus evident that the mentor has an important role to play in ensuring that candidate engineers meet the requirements for professional registration, and that the nature of the mentor-mentee relationship requires considered thought and attention.

III. MENTORSHIP: REVIEW OF THE LITERATURE

Mentorship can be defined as a relationship between an experienced member of an organization or profession, and an inexperienced member where the experienced member acts as a role model and provides support and direction to the inexperienced member [2]. The purpose of the mentoring relationship is to promote the development of the individual mentee [3]. Mentorship embodies a move toward social learning

theories, where learning is seen to take place through mediated interaction with others, as opposed to cognitive approaches to learning, which locate learning solely within individuals' cognitive processes. Mentorship also involves the acquisition of 'habitus' [4], a socio-cultural *way of being* that is required for successful entry into a community or profession [5]: put more simply, habitus is the cultural capital that allows engineers to 'act like engineers', or do 'what engineers do'.

The topic of mentorship has received extensive attention in the scholarly literature, including within the engineering disciplines. However, little such attention has been given to professional mentorship in engineering after graduation. Much of the literature focuses on peer mentoring within higher education [6, 7] or on the role that mentorship can play in promoting the participation of women [8, 9, 10] and other underrepresented groups [11] in engineering. Despite this, "the benefits of mentorship for protégés, mentors and their organizations are apparent" [12]. These benefits include the fact that mentorship maintains a productive workforce which in turn contributes to economic growth [12].

Comparatively little has been undertaken in the professional engineering domain. However, one such study, amongst Canadian engineers, finds that "the mentoring experience was generally perceived positively by all who had a mentor" [13]. One of the respondents in that study specifically mentions the need for mentorship to address technical aspects but also social aspects such as workplace dynamics. This is echoed in other research [14] in which mentoring is identified as particularly important in the development of engineering ethics and professional social responsibility. In short, therefore, mentorship has the potential to positively influence job satisfaction, on-the-job learning, and engineering professionalism.

Nonetheless, there are challenges regarding the study of mentorship. One of these, as emergent from the literature, is the need for sustained, lengthy engagement between mentors and mentees. Denson and Hill [2] argue that a minimum of 100 hours of engagement is required for meaningful change to be effected on the part of the mentee. Another challenge is that there is great variation in the use of mentoring, and in conceptions of the role of mentors [3]. This makes it difficult to draw specific lessons for making the most effective use of the mentorship experience.

The issue of role is an important one: just as individuals play multiple roles in their day-to-day lives, so too do roles shift within the mentor-mentee relationship. However, there is often an imbalance in power, where the mentor dictates the roles to be played by the participants. This has the potential to leave mentees unclear as to what roles are being played at any given time [15]. Herein lies the importance of studies such as the present one: by understanding mentees' perceptions of mentorship roles, mentors can be better prepared to guide them in effective ways.

In a study on mentoring between university faculty and students, Lechuga [15] shows that mentoring is usually conceived of in one of three ways, where the mentor is seen as an ally (that supports the student in achieving academic goals), an ambassador (that represents the culture of the academy) or as a master-teacher (that apprentices students into the methods of the academy). Another common conception of the role of the

mentor is that of coach [3], where the mentor ensures that teams remain on task and reach goals. (It is worth noting that all of these conceptions are expressed metaphorically, a point returned to later in this paper.)

One of the most widely used models of mentoring is that of Kram [16]. According to Kram, mentors exercise influence in two domains: career development and psychosocial development. Within each domain, the mentor fulfils a number of functions. In the case of career development, these functions include sponsorship, providing exposure, coaching, protection, and providing challenging assignments. In the latter domain, the mentor functions as role model, friend, and counsellor, and provides positive reinforcement. Each of these functions is explained further in Table 1.

It is against the backdrop of the aforementioned literature that this paper examines visual metaphors for mentorship that were produced by undergraduate engineering students who themselves were placed in mentor positions. This is done with a view to understanding how these students conceive of the role of the mentor. Before discussing the research design deployed, it is necessary to provide a brief sketch of the context for this research.

TABLE I.   Kram Model of Mentoring [16]

Domain	Function	Description
Career development	Sponsorship	Nominating mentees for rewards, such as promotion
	Providing exposure	Ensuring mentees are given assignments that expose them to key tasks and individuals
	Coaching	Helping mentees navigate the organizational environment
	Protection	Shielding mentees from tasks or individuals that are potentially damaging
	Providing challenging assignments	Assigning work to mentees that enables learning and skills development, as well as a sense of accomplishment
Psychosocial development	Role modeling	Embodying values, attitudes and behaviours
	Friendship	Being willing to interact with mentees about work, and non-work topics
	Counselling	Giving advice to mentees, both professional and personal
	Positive reinforcement	Helping to develop a positive sense of self on the part of mentees

IV.   Context: The Jozi Digital Ambassadors Project

The City of Johannesburg is the economic hub of South Africa, and one of the largest economic centres of the African continent. However, it is characterized by high levels of inequality, which manifests in various ways, one of which is the growing 'digital divide', where numerous residents of the City do not have access to internet services. This is due to income inequality, but also a lack of infrastructure and the high costs of telecommunication services in South Africa.

In order to address this challenge, the City of Johannesburg sought to roll-out free Wi-Fi services to over 700 000 residents in areas that previously had limited access to such services. As part of the project, up to 300 'Digital Ambassadors' were appointed to train residents on to how to access the Wi-Fi, and

how to use the Wi-Fi to access various services offered on the City's online portal. These Digital Ambassadors were un- and under-employed young people, and their appointment as Digital Ambassadors was also aimed at providing them with work experience and job skills.

In addition, up to 300 university students were appointed as mentors to the Digital Ambassadors. Each student was assigned to a team of approximately ten Ambassadors and provided support, encouragement and motivation to their assigned mentees. They also took up challenges experienced by the Ambassadors with the project management staff, and communicated information downwards to the Ambassadors. The focus of the mentors was on assisting the Digital Ambassadors in reaching their individual targets of training 240 residents on how to access the Wi-Fi and the City's online services portal.

A number of the university students that were appointed as mentors were drawn from the Engineering faculty. This was because the project was housed within the Faculty of Engineering and the Built Environment. Participation as a mentor was voluntary, and the mentors did receive remuneration for their efforts on the project. In the section that follows, greater information is provided as to the methods used for data collection.

V. RESEARCH DESIGN

As previously mentioned, this paper reports on an aspect within a larger project aimed at making free Wi-Fi services available to residents within the City of Johannesburg, South Africa's largest urban agglomeration. As part of the larger project, a number of engineering students were appointed as mentors to teams of unemployed youth who, in turn, were tasked with training residents as to how to use the free Wi-Fi.

These engineering students were interviewed so as to ascertain the benefits and challenges they experienced in being part of the project. As part of the interview, the students were asked to develop a metaphor for the project, and their involvement therein. They were given as much time as required to develop the metaphor and, upon completion, were asked to verbally explain the metaphor they produced and the various elements within it.

This paper reports on these metaphors, and the verbal explanation thereof. Non-engineering students also undertook the same interview process, but this paper focuses only on engineering students, and only on the metaphors for mentorship that they produced, and their discussion around those metaphors. This is so as to draw conclusions as to how these engineering students conceptualize the role of the mentor and what the implications thereof may be for their own future mentorship experiences during the candidacy period.

Metaphors were used to collect data as they provide insight into individuals' understandings of complex phenomena by placing them in familiar terms [17]. Metaphors are not merely 'decorative', but are useful means for understanding how participants think about certain topics: this is because metaphors are always partial depictions and, as such, highlight certain aspects over others [18].

Our conceptual systems, that determine how we think and act, are based on metaphor [19]. As a result, there are master metaphors that underpin our conceptions of the world. For example, one such master metaphor is the notion that 'up is good/better/more advanced', evident in phrases such as 'climbing the ladder of success' or 'higher education'. Furthermore, some concepts (such as communication and mentorship) are so abstract that we can only 'think' about them in metaphoric terms [17]. This explains why the models of mentorship that Lechuga [15] and Pembridge [3] develop are couched in metaphoric terms: allies, ambassadors, coaches and teachers. Such abstract notions are difficult to conceive of and humankind often resorts to metaphor to explain, or account for, these concepts. A simple, but common, example of this is the notion of *trust*. Trust, an abstract concept, can be broken, nurtured and built up, despite the fact that it does not exist as a physical entity.

The use of metaphor, therefore, allows access to underlying and unstated views on a topic and overcomes a common problem in data collection, namely that asking respondents directly is often the worst possible way to get desired information. Simply asking mentors to explain how they conceive of the role of the mentor often leads to them giving stock, clichéd responses. However, the development of a metaphor requires that respondents develop a conceptual model for mentorship, which gives greater indication as to how each respondent conceives of their role as mentor.

In total, ten metaphors were collected from engineering students who were employed as mentors on the larger Wi-Fi rollout project. Ten may seem a relatively small sample size, but it is in line with the samples taken in rich, qualitative research efforts, such as is undertaken in this paper. For example, a similar study [20] that examined metaphors for writing collected a sample of eight metaphors. In each case, the participants were also asked to discuss their visual metaphor, and this discussion was audio-recorded.

The collected metaphors were analyzed semiotically, that is, by grouping and classifying them in terms of how they depicted the mentor, and other stakeholders, within the project. Semiotics is concerned with the study of meaning [21], and was considered a useful analytical tool as it is based on the notion that the texts that individuals produce reflect their interest at that particular time, in that particular context [22]. The metaphors were thus examined with a view to understanding how they provided signs of the meaning ascribed to mentorship by the participants and their interest within the mentorship experience.

VI. RESULTS AND DISCUSSION

As already mentioned, the metaphors collected were analyzed by grouping them in terms of how they represented key aspects of the mentorship experience: the mentor, the mentee, and the relationship between the two. However, initial analysis of the metaphors was aimed at merely providing a brief description of what each student-mentor produced. To this end, it should be noted that two of the mentors did not actually produce a visual metaphor. One chose not to produce anything visual, leaving his page blank. Instead, he offered a verbal explanation of how the mentorship experience was akin to his initial entry into higher education. A second student produced a

flow chart that explained why he felt he needed to develop his mentorship skills, and what benefit he expected to derive from the mentorship experience. This flow chart is presented in Fig. 1.

Of the remaining metaphors, there was some commonality in the subject matter used to build the metaphor. For example, two of the student-mentors used soccer as a basis for the metaphor and, in both of these instances, the mentor was installed as the coach of the soccer team. As evident in the literature, mentorship is often aligned with the notion of coaching. Two further mentors produced tree metaphors. In one instance, the mentor was installed as the roots of the tree, while in the other, the mentor fulfilled the role of the person watering and benefiting from the tree. Two other metaphors focused on the organizational aspects of the larger Digital Ambassadors project itself. One focused on the city as the King, the project participants as the royal messengers and the installation and use of free Wi-Fi as the king's wish. The other installed the project as akin to an exercise in door-to-door sales, with the mentor as the supervisor of the salespeople. In the sub-sections that follow, these metaphors are grouped and classified in various ways so as to elucidate their potentials for enhanced understandings of mentorship in the context of the engineering profession.
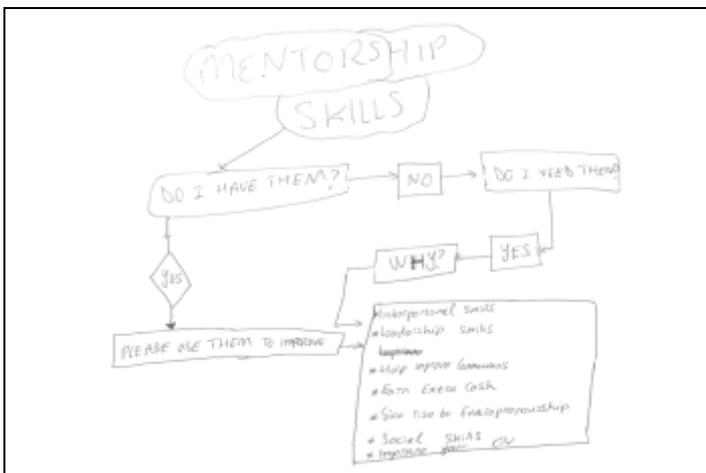

Fig. 1.   Flow chart produced instead of visual metaphor for mentorship

A. Role and Position of the Mentor

According to some definitions of mentorship, the role of the mentor is to provide support and direction to inexperienced mentees [2], the purpose of this being to promote the development of the individual mentee [3]. In the metaphors produced, the role of the mentor varies from central to peripheral. For example, in some of the metaphors, the mentor is central to the action that occurs. An example of this is presented in Fig. 2. In this example, the mentor is a drop of water that causes ripples throughout the pond. Here, the agency of the mentor is foregrounded: the mentor enacts change in the environment, in this case, in the mentees lives. The same can be said of the metaphor where the mentor is installed as the person watering the tree. In that example, it is the care and duty of the mentor that promotes growth on the part of the mentees.
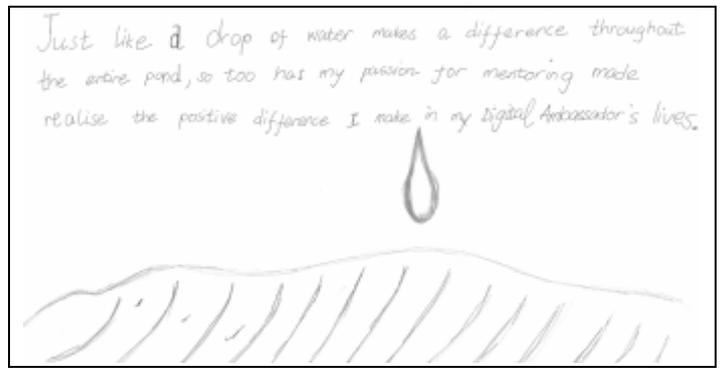

Fig. 2.   Water in a pond: A visual metaphor for mentorship

However, in other metaphors the mentor serves merely a support role. This is particularly evident in the soccer metaphors, where it is the players that are central to the action, while the coach (or mentor) observes and supports from the sidelines. In these metaphors, the mentor motivates the players, keeps them unified as a team, encourage those that are struggling and ensures that the mentees "focus on the goal". As such, the mentor plays an important role, but is not central to the 'action'. Fig. 3 represents an example of such a metaphor.
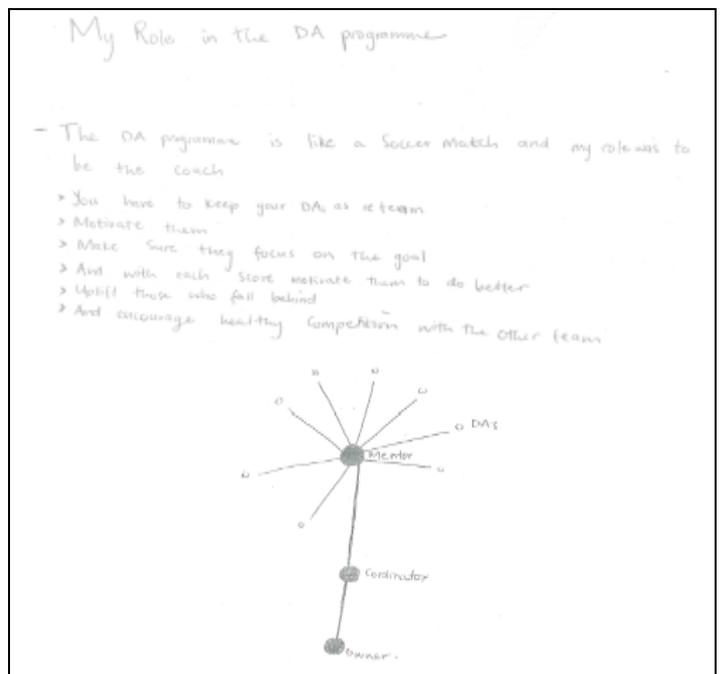

Fig. 3.   Digital Ambassadors as a soccer match: A visual metaphor for mentorship

In still other metaphors, neither the mentor nor mentee are foregrounded, with both, instead conceived of as parts of a larger system. This system can be either social or biological. An example of a biological system metaphor can be found in the previously mentioned tree metaphor, in which the mentor is conceived of as the roots of a tree, with the mentees being the trunk, branches and leaves of the tree. In that example, the student-mentor explains that "the roots collect enough nutrients and water enough to make sure that the tree is stable and strong enough not for it to die". In this example, mentor and mentee
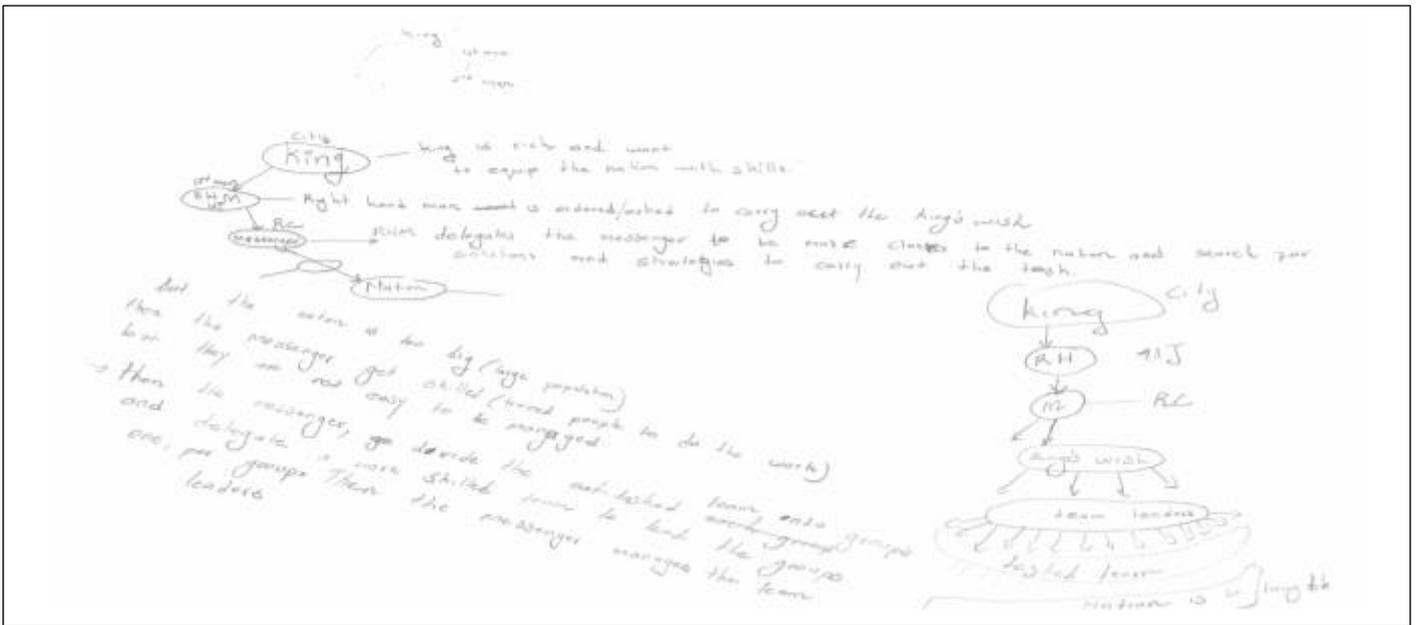
Fig. 4. The King's wish: A visual metaphor for mentorship

are part of the same biological entity and their functions are mutually dependent. Fig. 4, meanwhile, presents a social system metaphor. In that example, the social order is such that the king issues a command and a series of aides and messengers issue that command forth to the king's subjects. Here, the broader social system dictates the roles that each person in the system plays.

It is also interesting to note the ways in which the mentor appears in the metaphors. This ranges from central (literally and figuratively), such as in the water drop metaphor (Fig. 2), to part of an array of participants, such as in the King's wish metaphor (Fig. 4), to invisible, such as in the door-to-door sales metaphor (Fig. 5, below).
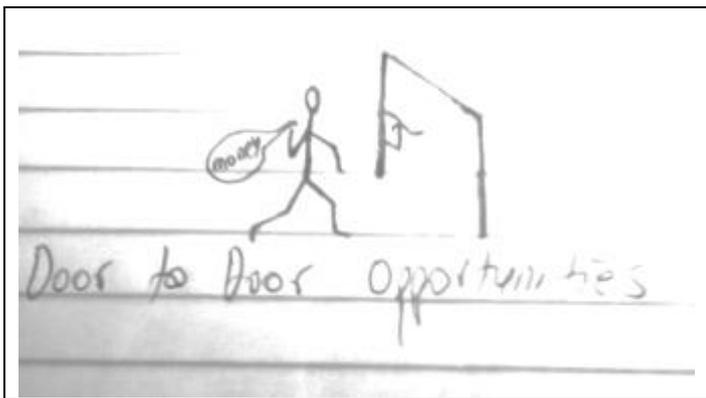

Fig. 5. Door-to-door: A visual metaphor for mentorship

In this latter metaphor, the student portrays the Digital Ambassadors project as an exercise in door-to-door sales, where the Ambassadors 'sell' the use of the Wi-Fi to residents of the City of Johannesburg. However, the mentor does not appear in the metaphor at all. If the metaphor is extended, the role of the mentor would appear to be that of supervisor, who provides 'training' and 'support', but who remains in the office, while the Ambassadors go out door-to-door. In this respect, this metaphor

is very similar to the soccer coach metaphors. However, it differs from them in two key respects: 1) the coach is more visible than the supervisor, and 2) in a soccer match, the team is accountable as a whole (including the coach), whereas sales people are held individually accountable.

B. Project Challenges, Goals and Structure

The use of metaphors also gave insight into how the mentors perceived the Digital Ambassadors project as a whole, and their role within it. Some of the metaphors focus on the goal of the project in quite specific detail. In Figs. 4 and 5, the goal of the project is the basis around which the metaphor is built, namely the need to equip the nation with skills, or the need to 'sell' public access Wi-Fi to residents. In other metaphors, a goal exists, but this is a generalized goal, such as in the soccer match metaphors. In these metaphors, the objective is to score goals so as to win the match, but it is left unsaid as to what 'winning' means for the project. Similarly, in the tree metaphors, the objective is to produce a flourishing, healthy tree, but there is little sense of what the project will look like in its flourishing, healthy state. In still other metaphors, the objectives of the project do not appear, either literally or metaphorically, such as in the water drop metaphor (Fig. 2).

The organizational structure of the Digital Ambassadors project is also foregrounded in some metaphors more than in others. For example, the King's wish metaphor focuses explicitly on the chain of command from the King, down to the subjects, with myriad participants in between: the University, the project administrators, the Ambassadors and the mentors. This is given less prominence in the soccer match metaphors, and is left out of the tree metaphors as well as the water drop metaphor.

Some metaphors also privilege the benefits that the individual mentor may gain from involvement in the project. This is particularly evident in the flow chart produced by one participant (Fig. 1) and, to a lesser extent, in the water drop

mentor, particularly in the written text that accompanies the visual metaphor, in which the student states that "my passion for mentoring made [me] realise the positive difference I make".

Furthermore, the metaphors reference external stakeholders in interesting ways. In Fig. 3, the mentor particularly mentions encouraging competition with other teams. In this respect, even though the Ambassadors have individual targets, the mentor sees them as a group with collective responsibility, and sees himself as being in competition with other mentors and their groups of Ambassadors. This is different from the other soccer metaphor, where no mention is made of 'the opposing team', even though such opposition is implied in the nature of the metaphor. Similarly, in both tree metaphors, the trees are taken in isolation and little attention is given to their broader environment.

Finally, it is interesting to note that none of the metaphors produced by the engineering students include reference to any form of challenge or obstacle to be overcome. We make this observation because the metaphors produced by non-engineering students were replete with such metaphors. In one metaphor produced by a non-engineering student, the mentor is the captain of a ship during a storm, in shark-infested water (see Fig. 6). In another, the mentor helps the Ambassadors who in turn help the residents to cross a raging river with slippery rocks. In such metaphors, the challenges, obstacles and perils are clear and present, and it is curious that none of the engineering students' metaphors reference any form of such obstacle. (Note that an equal number of metaphors, ten, were collected from non-engineering students.)
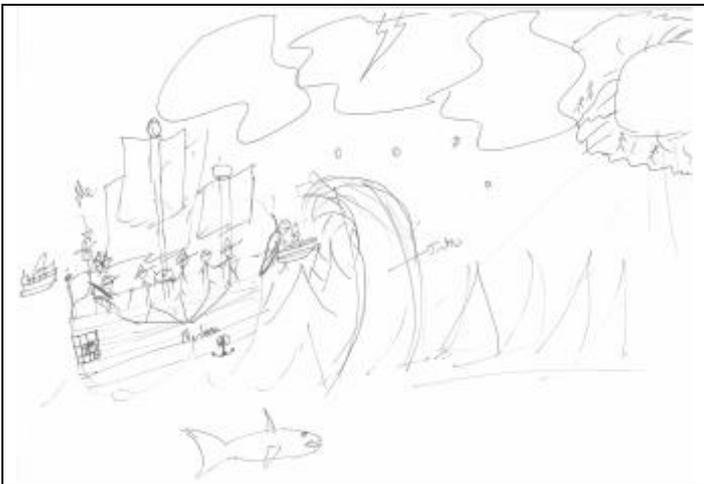

Fig. 6.   The ship's captain: A visual metaphor for mentorship

VII.   CONCLUSIONS AND IMPLICATIONS

The engineering profession places significant emphasis on mentorship. In most countries, engineering graduates have to accumulate a number of years of work experience before becoming registered as engineering professionals. The accumulation of this work experience often involves working under the guidance of a mentor and, in South Africa, it is required that candidate engineers be assigned to such a mentor during their candidacy period. Beyond the candidacy period, mentorship is becoming a core aspect of modern workplaces, including within engineering.

More attention thus needs to be given to mentorship and, in particular, how the role of the mentor is conceived. This paper has begun this task. It has done so, by examining metaphors for mentorship produced by engineering students appointed to work as mentors to a group of unemployed young adults who were tasked with training residents within their communities regarding how to access free Wi-Fi provided by the City of Johannesburg, as well as the City's online services portal.

Metaphors were identified as a useful avenue for accessing conceptions of mentorship as metaphors are, per definition, partial representations of a phenomenon. As such, they foreground certain aspects, while de-emphasizing other aspects of the target phenomenon. This was evident in the metaphors collected in this project: some of the metaphors emphasized the goals of the project, and the role of the mentor in achieving those goals, while others emphasized the impact that mentors can have on the lives of mentees. Of course, in this regard, the two are not mutually exclusive: the mentor impacts on the life of the mentee by helping that person achieve their personal goals which are often aligned with the goals of the organization/s to which they are affiliated. In a metaphoric representation, however, one aspect must be privileged over others. This was evident in the two soccer metaphors, where only one emphasized the opposing team while the other de-emphasized the competitive aspect of soccer, choosing instead to privilege the player-coach relationship.

In the same way, entering into the candidacy period involves all of the aspects mentioned in the metaphors discussed herein. The engineering mentor should assist mentees navigate the organizational structures and goals in which they work (as in the King's wish metaphor), provide opportunities for mentees to perform independently with the knowledge that advice and guidance is available should it be needed (as in the soccer metaphor), and should act as a role-model that effects positive change in the life of the mentee (as in the water drop metaphor). They should also promote the mentee as far and wide as possible (as in what the literature terms an ambassador role [15]) and should teach the mentee when the mentee's knowledge and skill is lacking (as in what the literature terms a master-teacher role [15]).

The use of metaphor makes these roles clearer than they may have been had interviewers merely asked mentees or mentors how they conceive of the mentorship relationship. Metaphors also provide insight into the particular interests of individuals within this relationship. For example, an individual that foregrounds competition or organizational hierarchy may best be served by a mentor that fosters such competitive behaviour, or includes the mentee in the organizational hierarchy. However, care should be taken to avoid seeing metaphors as all-inclusive and unproblematically predictive.

In conclusion, this paper also presents a form of data collection and analysis that may be foreign to many engineering educators and engineering professionals. We hope that the analysis undertaken herein demonstrates the value of such qualitative methods in deepening and enriching understanding of the social aspects of engineering activity.

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