



# **Work In Progress: Developing an Instrument to Measure Mentoring Experience's Impact on Leadership Development among Engineering Graduate Student Mentors**

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## **Introduction**

This work-in-progress (WIP) paper introduces an instrument to measure the impact of experiences serving as mentors on leadership development among Engineering graduate students. Leadership is a key component of engineering career success [1-2]. Engineering graduates are reported to lack leadership and other professional skills entering the industry, which resulted in them spending much working time to advance these professional skills [3-4]. Engineering educators have called for contributory ways to groom leadership understanding and competencies among engineering students, without further squeezing the already dense engineering curriculum [5-6]. Mentoring opportunities provide an alternative approach. Studies showed that mentoring experience in engineering research settings has the potential to develop leadership among mentors [5, 7-8]. However, the resulting impact and what part of the leadership is developed based on this impact are still unknown.

An earlier exploratory qualitative study conducted by the authors revealed that serving as mentors provided opportunities and experiences for engineering graduate student to both broaden their understanding of leadership and practice and advance their leadership skills [1]. The reported changes in the understanding of leadership included gaining the awareness of new aspects, embracing extra roles, correcting prior beliefs, and reevaluating the fit [1]. Various leadership-related skills such as project management, communication, relationship-building, organizing, and leading were also described by the study participants. A subsequent quantitative study was designed to investigate to what extent serving as mentors helps engineering graduate students develop their leadership understanding and skills. This WIP paper proposes an instrument that will be used in the subsequent quantitative study. The instrument was built based on both existing instruments and the aforementioned qualitative study findings.

## **Study Population**

Engineering graduate students from NSF-funded Engineering Research Centers (ERC) will be recruited to participate in the study, similar to the prior qualitative study. ERCs set a regular platform offering opportunities for engineering graduate students to work as mentors in an engineering research setting [1]. Engineering graduate students mentor various summer interns which include high school students, undergraduate students, and K-14 teachers. These mentoring experiences take place in similar lab settings, require similar research outcomes, and follow the same mentoring procedure. Therefore, ERC graduate student mentors offer an adequate study sample with their diversified but also homogeneous mentoring experiences.

## **Research Question**

The main research questions this subsequent quantitative study aimed to answer are: 1) Does serving as an ERC summer program mentor help engineering graduate students develop

leadership understanding and skills? 2) To what extent does serving as an ERC summer program mentor help engineering graduate students develop leadership understanding and skills? The second research question investigates what aspects of the leadership understanding and skills the ERC graduate students develop through serving as mentors and to what degree such a development achieves.

Both research questions will be investigated through a retrospective pre-post survey which will be conducted with both ERC graduate student mentors and non-mentors, asking them to rate both their level of leadership understanding and skills before joining the ERC and their current level of leadership understanding and skills. All participants are current ERC graduate students. Questions about experiences in ERC activities outside the summer mentoring program will also be asked among all the participants to control the influence of leadership development from non-ERC summer program mentoring experience. The pre scores and post scores on the leadership understanding and skills of all participants will be analyzed to examine if engineering graduate students significantly improved their level of leadership understanding and skills by serving as summer program mentors, compared to their colleagues who never mentored in any of the ERC summer programs.

## **Instrument Development**

The improved level of leadership understanding and skills was defined and measured as the engineering graduate student having a more advanced view of leadership and embodying leadership actions/skills more often [2]. The instrument, therefore, was designed to capture various views of leadership and aspects of leadership actions/skills. The “Leadership Identity Development Model” [10, p.7-20], was used to frame the multiple views of leadership. At the same time, Leadership Competencies Builder [11], which was used as the theoretical underpinning in the prior exploratory qualitative study, was referenced to structure the aspects of the leadership actions/ skills in the instrument.

Several stages of leadership identity [10] were demonstrated by participants in the prior exploratory qualitative study. ERC graduate student mentors reflected various stages of leadership identity, ranging from “stage three: Leader Identified” to “stage five: Generativity” [10, p.14]. “Stage three: Leader Identified” was achieved among all participants as all of them viewed leadership as the behaviors or actions of an individual or a group of individuals who hold a leadership position and recognized the hierarchical structure within a working group [9]. “Stage four: Leadership Differentiated” and “stage five: Generativity” were also reached by a very few participants. A few participants gained an awareness of leadership could be bidirectional and not necessarily always initiated and/or applied by the “positional leaders” [10, p.14]. Several participants expressed enthusiasm to make an influence and dedication to developing others in their workplace. Despite both being the minority, participants who demonstrated stage four and/or five leadership identity gave the credit to their experience of being a mentor in ERC summer programs.

The Leadership Identity Development Model [10] was used to frame the views of leadership captured in the instrument. The quantitative study will recruit all ERC graduate students, mentors, or non-mentor, to participate. Stages three through six of leadership identity

were included in the instrument to align with the prior qualitative study findings. The instrument items captured four different views of leadership: 1) leaders hold positions and do certain things; 2) leadership can happen without a position of leader; 3) leadership enriches the life of a group; 4). leadership is lifelong learning.

Leadership Competency Builder [11] was used as the theoretical underpinning in the prior exploratory qualitative study. All five meta-competencies: 1) Leading self, 2) providing strategic focus, 3) connecting with others, 4) leading others, 5) delivering results, emerged from the qualitative data. The instrument contained items instantiating all these five meta-competencies.

The items in this instrument are a combination of items referenced from existing instruments and items that are self-developed based on the prior exploratory qualitative study findings. The existing instruments include the “Engineering Leadership, Change, and Synthesis instrument” [2, p.126-128] and the “Student Leadership Outcomes Measure” [12, p.544-546]. 25 of the items were referenced from the above two sources. Self-developed items were created to reflect the discoveries from the prior exploratory qualitative study findings. The findings include four aspects of changes in ERC graduate student mentors’ leadership understanding discovered in the prior exploratory qualitative study findings: noticing the importance of having empathy, realizing the obligation of developing and teaching others, understanding the downside of “leading by examples” mindset, and reevaluating personal fit to leadership positions [9]. Six items that reflected four changes were added to the instrument. It is worth noticing that a portion of the concept of developing and teaching others was also covered from the items referenced from the existing instruments.

The qualitative study also reflected a common “leaders-centered” [6, P.2] view toward leadership among ERC engineering graduate students, which was reflected by all participants describing their understanding of leadership from the perspectives of who leaders are and what leaders should do [9]. The “Leader-centered” view has very little touch on the views of leadership being a social process [13] or a culture of sharing [6], both of which emerged in recent leadership theory research. Moreover, the “leader-centered” view of leadership matches stage three of the Leadership Identity Development Model [10]. The social process and culture of sharing views of the leadership align with stage four. The instrument then incorporated four items that obtained the social process and sharing views of leadership. Embedding the social process and culture of sharing views of items into the instrument provides an opportunity to measure the average level of understanding among ERC engineering graduate students on advanced theory of leadership. The measure and the consequent results will offer insights to help redesign and improve the ERC mentor experiences. One implication for the whole study (qualitative and quantitative) is to explore the potential of setting and designing mentoring opportunities as an alternative strategy for leadership training. The prior qualitative study findings indicated that a certain extent of instructional contents and activities are needed to incorporate into ERC mentoring experiences to introduce an adequate and sophisticated understanding of leadership to graduate student mentors, which in turn would assist the formation of their leadership competencies [9].

## Next Step

The instrument is currently going through the phase of collecting content validity evidence, under review by three independent experts, each with expertise in organizational leadership, engineering leadership, and instrument development, correspondingly. A retrospective pre-post survey centered on this instrument is planned to be administered to engineering graduate students among all 14 current ERC with the help of the centers' leadership team. Participants will be asked to rate their level of knowledge about leadership and their frequency of embodying leadership skills in daily work both before joining the ERC and at the current time. Exploratory Factor Analysis and Cronbach Alpha analysis will be conducted after the quantitative data is collected to provide evidence for both construct validity and reliability. The pre scores and post scores over the leadership knowledge and skill items from all participants will be analyzed to examine if ERC engineering graduate students significantly improved their level of leadership understanding and skills by serving as summer program mentors, compared to their colleagues who never mentored in any of the ERC summer programs. The whole and final version of the instrument will be presented at the conference.

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