Advancing Leaders in Engineering: Ways of Learning Leadership

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Abstract:

This paper explores the leadership practices of women engineers licensed in British Columbia, Canada and reports on a quantitative correlational study using the Leadership Practices Inventory to operationalize leadership and explore associations with levels of university education, executive coaching, years of engineering practice, and the location of practice as rural versus urban. The number of women leaders in Canadian corporations continues to increase, while the influence of women engineer leaders is less progressive. Growth in the fields of engineering leadership education, management education, and leadership education offered sufficient evidence to pursue research that furthered the leadership development of women engineers. In university engineering education inclusion of leadership education improved, while attention to leadership development for practicing professional women engineers remains sparse. The participants assessed their leadership practices and a correlational analysis will associate their leadership to levels of education programs, executive coaching, years of professional practices, and location of practice in terms of rural or urban. I conclude with a proposed conceptual framework for learning leadership.

Key Words:

Leadership Practices Inventory; Women in engineering; Learning Leadership; education; coaching.

Introduction

Leadership is a process that takes place over a period of years; it is continuous while cyclic and requires attention to the unique strengths and context of the leader (Rowe, Heykoop & Etmanski, 2015). Leadership education is the combination of learning and development that fosters leadership growth for a target population or cohort of leaders. Henein & Morissette, (2007) described leadership in Canada as an invisible field of study with a lack of leadership education and developmental pathways for leaders; and they stressed the importance of a community of practice to renew and sustain leaders. One remedy to improve the supply of leaders is more leadership education in undergraduate and graduate programs and more continuing education for professionals who are already in private practice. The purpose of this paper is to propose a conceptual framework for learning leadership, a framework emerging from post-doctoral research on a group of women engineer-leaders in British Columbia, Canada (MacIntyre, 2014).

Background

Evidence of the increase of women leaders in American organizations shows that slightly more than one half, 51.4% of the management, professional, and related occupations are held by women (Catalyst, 2014). In the engineering profession, the influence of women is less in evidence; and women engineers continue to seek support and direction for leadership development from their engineering associations and affiliated societies (Calan & Levac, 2009). Of the total number of licensed engineers in Canada only 11% are women and engineering continues as the profession in which the number of women is under-represented (Lambert, 2009; Tarnai-Lokhorst, 2014).

Background research drew upon theories of transformational leadership, management and leadership, and engineering leadership from the author's doctoral research (MacIntyre, 2014). Adult learning theory, experiential learning theory, cognitive learning theory, and constructivist theory contribute to the curriculum for learning leadership. Constructivist learning includes learning collaboration skills through instructional techniques that integrate perception, beliefs, and previous experience. In engineering education, constructivist approaches represent a significant departure from the tradition of learning scientific principles and application protocols (Gredler, 2005; Tan, 2006).

The theory of transformational leadership is foundational, acknowledging the developmental nature of leadership and the importance of relationships between leaders and followers (Avolio, 2005). Burns (1978) published seminal research on leadership and introduced a continuum of leadership styles ranging from transactional to a full range, transformational approach. As cited in Jandaghi, Matin, & Farjami (2009), Burns' first concept of transformational leadership emphasized the dual roles of leaders and followers moving in alignment intellectually and in pursuit of a higher level of purpose. Densten and Gray (2001) examined the importance of integrating reflective practice in leadership development programs and noted the constructivist learning approach that links leadership theory to the student's experience. Brookfield (1995) integrated reflective practice into education for new teachers and claimed that the teachers improved their ability to facilitate student learning. Known as double loop learning, the process involved the teachers in shared reflection and group learning (Hughes, Ginnett & Curphy, 2005). Through the double-loop learning, leaders learned the value of relationships how to while also question personal attitudes and beliefs.

Cunliffe (2009) goes beyond reflective practice to emphasize critical thinking, in contrast to Schon's (1983) approach of a professional's reflection-in-action. She teaches leadership using a philosopher's metaphor of three intertwining threads of relational leadership, moral activity, and reflexivity. Reflexivity incorporates critical conversations and includes attention to the leader's moral activity and perhaps indicative of the business history of the previous decade. Eriksen and Cunliffe (2010) deepened understanding of leadership and strengthened the constructivist pedagogy of leadership. The theoretical framework for the doctoral is represented in Figure 1: *Theoretical Framework* (MacIntyre, 2014)

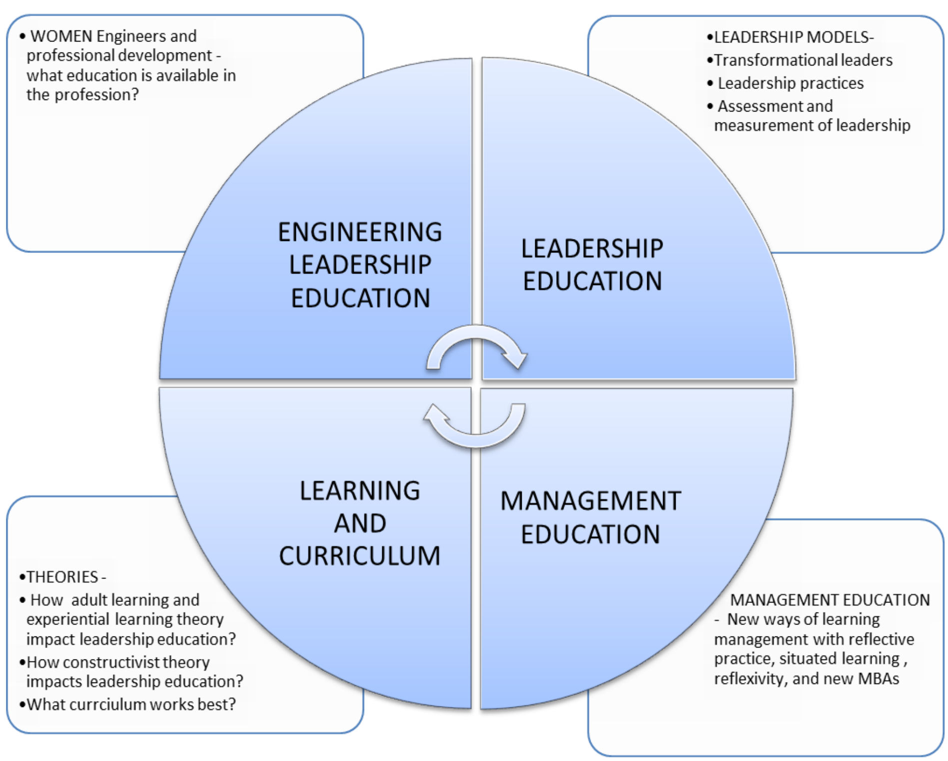


Figure 1: Theoretical Framework

The research was designed to profile the leadership of a sample of women engineer-leaders and investigate the sources of learning that influenced their leadership development. Data collection took place in 2014 and 2015. Data analysis included descriptive statistics of the variables related to professional practice: location of practice as urban or rural, area of engineering, and presence of executive coaching; see Table 1: *Descriptive Statistics of the Location of Practice, Area of Engineering, and Presence of Executive Coaching .* Other variables considered for association with leadership development were the years of engineering practice and hours of executive coaching, as shown in Table 2: *Descriptive Statistics of Continuous Variables.* All variables were tested for association with the leadership practices of the women engineer-leaders and significance was not found.

Table 1: *Descriptive Statistics of the Location of Practice, Area of Engineering, and Presence of Executive Coaching*

Variables	*n*	%
Urban		
No	9	16
Yes	47	84
Engineering Area		
Aerospace and Defense	2	4
Chemical	7	13
Civil	23	41
Computer Science and Software	3	5
Electric and Telecommunications	5	9
Environmental	7	13
Geotechnical	1	2
Mechanical and Manufacturing	7	13
Mining	1	2
Education Level		
Baccalaureate	29	52
Diploma	1	2
Doctorate	1	2
Master's	25	45
Executive Coaching		
No	39	74
Yes	14	26

Note. Due to rounding error, percentages may not add up to 100.

The research revealed the top leadership practices of the women engineer-leaders; and the completion of the leadership practices inventory contributed to their leadership learning. For Canadian engineers, leadership development is a recent topic; learning leadership requires both formal and informal education that goes beyond the traditions of an engineer’s university experience and the engineer-in-training program. Advancements in the application of learning and curriculum improvements combine to provide ways of learning leadership that accelerate leadership development (Kassotakis & Rizk, 2015). Formal education provides the leader access to the theory and practice of leadership in existing management and leadership education programs. With guidance and learning the engineers will create the context that matches women engineer-leaders. The missing elements of leadership development are access to the facilitated learning and the group learning that enhances visioning and relationship building, particularly in community with other engineer-leaders. According to Ely and Rhode (2010), leadership development for women is the combination of learning conceptual frameworks of leadership, practice to integrate and apply the skills of leadership, self-discovery of one's leadership identity, and support through coaching and mentoring to sustain the leader's growth.

Leadership Practices

The researcher used the Leadership Practices Inventory (LPI) to provide a descriptive, quantitative assessment of the leadership capacity of women engineer-leaders. The inventory is published as the LPI-Self, and herein referred to as the LPI; a second format is the LPI-Observer, a 360 degree format used by followers to assess a leader and not applicable in this research. Kouzes and Posner (1987, 2002) developed the transformational leadership model known as the leadership challenge from their research on personal-best experiences of leadership. They created the leadership practices inventory to reflect the transformational leadership of accomplished leaders, behavioral statements and actions of successful leaders. The LPI consists of thirty statements that are rated on a 10 point Likert scale; the assessment groups the statements into five leadership practices or subscales as follows: modeling the way, inspire a shared vision, challenge the process, enable others to act, and encourage the heart.The authors claim leadership is a learned behavior developed through the study of the five practices and evidence continues to support their claims.

Reliability

Kouzes and Posner (2002) reported the reliability coefficients for the LPI-Self in the range from 0.75 to 0.87 and for the LPI-Observer to range from 0.88 to 0.92 (p. 6). The authors claimed that the variation in reliability coefficients was not detrimental to the LPI, giving the justification that reliability remained consistent for demographic variables of gender, marital status, educational levels, countries, and without re-testing differences (p.7-8). Posner's (2010) data analysis supported the earlier claims with respect to demographic variables and he reported that the LPI-Self reached a reliability coefficient for the five subscales as follows: .84 for modeling the way, .91 for inspire shared vision, .86 for challenge the process, .86 for enable others to act, and .91 for engage the heart (p. 5).

In this study five leadership practices subscales were created: model the way, inspire a shared vision, challenge the process, enable others to act, and encourage the heart. The composite scores on the newly created subscales were tested with Cronbach's alpha reliability using George and Mallery's (2010) guidelines on reliability, where alpha values greater than .90 indicate excellent reliability, alpha values greater than .80 indicate good reliability, alpha values greater than .70 indicate acceptable reliability, alpha values greater than .60 indicate questionable reliability, and alpha values less than .60 indicate unacceptable reliability. This study determined Cronbach's alpha reliability for the sample of women engineer-leaders of .48 for modeling the way, .90 for inspire shared vision, .70 for challenge the process, .53 for enable others to act, and .79 for encourage the heart; see Table 2: *Cronbach's Alpha Reliability Coefficients, Means, Standard Deviations and Leadership Practices Inventory.*

Table 2: Cronbach's Alpha Reliability Coefficients, Means, and Standard Deviations and Leadership Practices

Scale	Number of items	Reliability α	Mean	Std Deviation
Model the Way	6	.48	7.48	0.84
Inspire Shared Vision	6	.90	6.07	1.80
Challenge the Process	6	.70	6.88	1.26
Enable Others to Act	6	.53	7.93	0.84
Encourage the Heart	6	.79	6.88	1.17

The Leadership Practices Inventory is a psychometrically evaluated instrument (Fields & Herold, 1997; Kouzes & Posner, 1993, 2002). Kouzes and Posner (2002) identified face validity of the LPI as accounting for most of the validity, due to the subjective evaluation of the LPI by leaders who participated previously in the authors' research. They reported that participants identified with the language in the thirty statements, which described their own or another leader's personal best experience; thus, it was concluded that the LPI had face validity (p. 14). Other measures of the validity included the statistical measure of factor analysis to support the discriminatory validity of the LPI (Field & Herold, 1997; Carless, 2001; Herold & Fields, 2004). Vito and Higgins (2009) used factor analysis to test the construct validity of the LPI for use by a specific group of police managers. They found that the LPI was valid for police leadership performance and a valid construct for assessing the leadership capabilities in law enforcement agencies (p. 317). The LPI has proven construct validity for groups in nursing, teaching, educational leadership, and law enforcement despite significant changes in the business environment over the past decades (Clavelle, Drenkard, Tullai-McGuinness & Fitzpatrick, 2012; Duygulu & Kublay, 2010; Tourangeau & McGilton, 2004; Posner, 2010; Vito & Higgins, 2010).

Results of the Leadership Practices Inventory

In this study the Leadership Practices Inventory (LPI) was an important starting point for the women engineer-leaders to learn a language of leadership. The results of the LPI showed that enable others to act was the dominant leadership practice; this practice describes their collaborative style of interaction and engagement, a reliance on trust and commitment, and respectful behavior to their followers. The results indicate the engineers' Canadian sensibilities, an ease with valuing relationships across cultures, disciplines, and the many domains that engineering touches. Their actions included strengthening the relationship with their followers through active listening, attention to diverse perspectives, and supporting decisions made by followers. These leader behaviors represent their comfort with strengthening their followers' capability, including their followers' aspirations for leadership, an important role of a transformational leader (Jandaghi, Matin & Farjami, 2009).

To determine if significant differences between the five leadership practices, a Pearson correlation matrix was created among modeling the way, inspire shared vision, challenge the process, enable others to act, and encourage the heart. Since each variable was used four times, a Bonferroni correction to the alpha level was used; thus the new alpha level is .013 (.050 / 4). Modeling the way was significantly positively correlated with encourage the heart. Inspire shared vision was significantly positively correlated with challenge the process and encouraging the heart. Challenge the process was significantly positively correlated with enable others to act and encouraging the heart. Enable others to act was significantly positively correlated with encourage the heart. The full correlation matrix appears in Table 3: *Pearson Correlations among Modeling the Way, Inspire Shared Vision, Challenge the Process, Enable Others to Act, and Encourage the Heart*.

Table 3: Pearson Correlations among Modeling the Way, Inspire Shared Vision, Challenge the Process, Enable Others to Act, and Encourage the Heart

LPI subscales	**Model the Way**	**Inspire Shared Vision**	**Challenge the Process**	**Enable Others to Act**	**Encourage the Heart**
Model the Way	-				
Inspire Shared Vision	.23	-			
Challenge the Process	.31	.83*	-		
Enable Others to Act	.25	.31	.51*	-	
Encourage the Heart	.41*	.45*	.48*	.55*	-

Note. * $p < .013$

Although the second highest leadership practice was modeling the way, the lower reliability on this subscale suggested the participants did not interpret the leader behaviors consistently. One statement under challenge the process was to experiment and take risk (6.13). This statement is noteworthy with respect to the perception of risk, which differs substantially between engineering and business. For the professional engineer the highest purpose is safety and security of the technology application, given that engineering standards and protocols minimize risk. Although anecdotal, a note from one woman engineer reinforced this difference when she wrote that no risk was taken in engineering while plenty of risk was common in her business.

The results of the LPI also reveal that the engineer-leaders are less attentive to articulating vision; this implies that they do not view their leadership beyond the future possibilities of a specific technology. It is the identity work that is an essential part of leadership development and through identity work leaders learn to understand their context and develop a shared vision with their followers. For example, when the context is a diverse group of stakeholders who question the implications of a technology, the engineer's role is to lead the public policy conversation with an open systems mindset, going beyond an engineering explanation of technical standards. The context requires conveying a vision for the technology that aligns with the social implications on the leader's role as a visionary, connecting technology and society (Bonasso, 2002; Reeve, 2010).

The descriptive statistics of LPI scores produced a profile of leadership for the women engineer-leaders. In terms of the highest mean scores of the five subscales, enable others to act was the dominant leadership practice in this study; see Table 4 *Descriptive Statistics of Continuous Variable.* Enable others to act describes the leader's collaborative style of interaction and engagement. Specific leader behaviors within this leadership practice included building trusting relationships with followers, actively listening to and responding to diverse points of view, supporting decisions made by followers, and promoting the follower's growth as a leader (Kouzes & Posner, 2011, 2013). The leader behaviors of enable others represent the leader's comfort with strengthening her followers' capability, including the followers' aspirations for leadership (Jandaghi, Matin & Farjami, 2009).

Table 4: Descriptive Statistics of Continuous Variables

Variable	Minimum	Maximum	Mean	Std Deviation
Years in practice	8.00	40.00	20.73	7.09
Hours of Executive Coaching	1.00	500.00	115.71	169.87
Modeling the Way	5.60	9.40	7.48	0.84
Inspire Shared Vision	2.50	10.00	6.06	1.80
Challenge the Process	3.67	9.33	6.88	1.26
Enable Others to Act	5.67	9.67	7.93	0.84
Encourage the Heart	3.50	8.83	6.88	1.17

Posner, Crawford, & Denniston-Stewart (2015) used the Leadership Practices Inventory to assess leadership development of undergraduate students in arts, business, engineering, and education. Even though the engineering students recorded the lowest scores in the leadership practices at the beginning of the academic year, they showed the highest increase in the five leadership practices by the end of the year. The results suggest the engineering students adapt readily to the demands of their workload through skillful interdependency, evidenced in formal and informal collaborative behavior (p. 175).

Learning Leadership in Engineering

The recognition that engineers needed to develop leadership capacity is a theme that heightened in the late twentieth century when competition of engineering services became global. Bonasso (2002) foresaw the challenges that globalization presented for engineers, who were perceived as only technical problem-solvers and not equipped to lead. He argued that technology applications had broader social and the cultural implications and a complexity that was not present in earlier times. He believed engineers made more than physical contributions and that engineers had to take the lead and change perceptions of their public role.

One response to the global competition of engineering services was an increase in the number of engineers who added a post-graduate engineering specialization. A specialization increased the engineer's technical expertise rather than broadening their skills to adapt to the global and business context. Contributing to the general problem was engineers' perception of leadership training as a soft skill with less value in a technical field. Specifically, the challenge for technology organizations and professional engineering leaders was to identify the preferred strategies needed to develop engineers as leaders or to risk using leaders without the technical technology expertise for strategic planning and decision-making. For large technology organizations, globalization resulted in structural changes that facilitated individual and organizational adaptation to change. For example, at Texas Instruments the organizational structure was stripped of hierarchy to create cross-functional teams that provided opportunities for women to advance (Foust-Cumming, Sabatini & Carter, 2008; Moss Kanter, 1997). Employers of all sizes expect engineering graduates to have equal skill in technical expertise, business knowledge, and leadership capability. Dunn (2009) foresaw the future when technical expertise became a commodity and educators must adapt engineering programs to graduate engineers who are ready to lead in engineering and society (Khattak, Ku, & Goh, 2012).

Farr and Brazil (2009) characterized the impact of globalization on engineering practice as negative and disruptive and proposed that engineers develop leadership capability through a combination of training, experience, and career growth. In the US, university educators recognized the different demands that engineers faced and engineering curriculum expanded to include leadership and the scholarly discipline of engineering leadership recently emerged (Haghighi, Smith, Olds, Fortenberry & Bond, 2008). Since 1995, Pennsylvania State University (PSU) offered a minor in engineering leadership development in the undergraduate degree. Learning outcomes addressed technology management, shared leadership in teamwork, creativity, innovation, and leading diversity. The PSU curriculum provides an example of a rich combination of engineering, leadership, and cross-cultural studies.

Other advances in the curriculum for engineering leadership combined a mix of applied sciences, engineering, entrepreneurship, and social sciences like a virtual team experience through the Internet technology of Skype. Crumpton-Young, McCauley-Bush, Rabelo, Meza, Ferreras, Rodriguez, Milan, Miranda, and Kelarestani (2010) defined engineering leadership in the context of leading a technical team based; they surveyed engineering students and professional engineers whose priorities included communication, problem solving, and a keen awareness of their role as a leader. In Australia and European universities educators reported on the lack of engineering leadership programs in contrast to advancements in American engineering schools (Khattak, Ku & Goh, 2012).

In Canada, the most progressive leadership education for engineers began at the University of Toronto in 2004 where faculty in the department of applied sciences and engineering began a certificate program, known as Leaders of Tomorrow (LOT Program). It incorporates learning to lead teams, the social and psychological dynamics of relationship building, and the identity of leader. Reeve (2010) stressed the urgency for engineering leadership education and emphasized the social responsibility of engineers to lead public policy debates on the impact of new technology on Canadian society. He claimed that a bond of trust existed between engineers and the Canadian public, a bond that might be lost without sufficient engineering leadership.

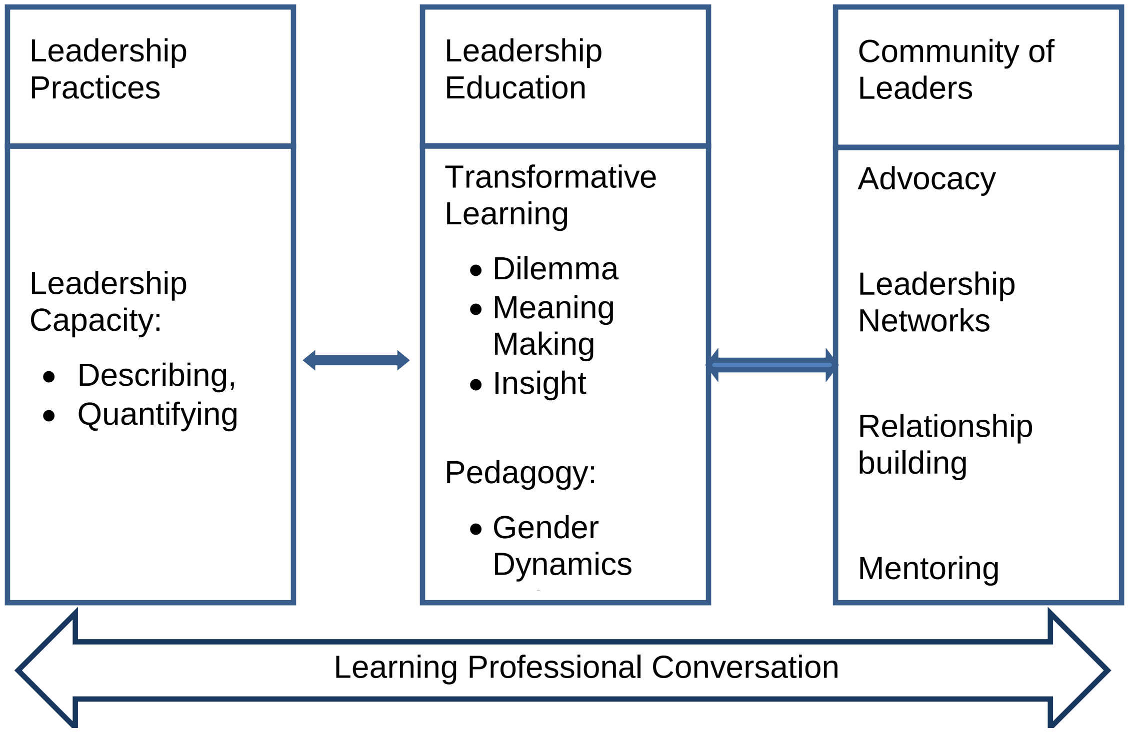
Touchie, Pressnail, Beheshti, and Tzekova (2010) argued for engineering leadership that focused on sustainability and a holistic thinking, a contrast to the business orientation of leadership education in the US. Numerous factors contributed to changes in the practice of engineering and educators recognized that leadership capacity was essential for Canadian engineers (Fishbein & Chan, 2010). Projects have implications across national and cultural boundaries; and large-scale engineering projects raised ethical issues that questioned the role of engineers. Lessons from the LOT Program indicate that leadership education begins in the undergraduate engineering education and strengthens with active faculty involvement.

Conceptual Framework for Learning Leadership

For women engineer-leaders to build on their leadership strengths they require ongoing education that draws upon the pathways already defined in engineering leadership education, management education, and leadership education. Sustainability is a Canadian theme that extends to all realms of engineering practice and business, including succession of women leaders in the engineering profession. Only through leadership development that is grounded in Canadian engineering and education values will women engineers create a legacy within the profession (Alexandrou, Swaffield, & MacBeth, 2014).

I propose a conceptual framework for learning leadership, a framework for learning leadership from sources of learning and development for leaders in a wide range of contexts. These dimensions include the following: firstly, leadership practices to describe and quantify the leadership of the individuals and to begin to characterize the leaders as a group; secondly, curriculum for leadership education that is grounded in transformational learning, includes gender sensitive pedagogy, and executive coaching; and thirdly, formation of a community of leaders who advocate and furthers leadership learning. A graphic of this conceptual framework appears in Figure 2: A *Conceptual Framework for Learning Leadership.*

Figure 2: A Conceptual Framework for Learning Leadership



Transformational Learning

Transformational learning originates with Mezirow (1991, 2000), it is a learning process in which the learner faces a dilemma, discovers ways of making meaning of the dilemma, and achieves insight that transforms the learner. For women leaders, transformative learning offers a way to achieve their leadership potential while also addressing the internal change that is essential for their growth. Debebe (2009, 2011) explored transformational learning and the influence of environment in a women-only classroom. She proposed an analytical framework that reinforces the values of safety for women to transform themselves and grow as a leader. Kassotakis and Rizk (2015) researched women-only leadership development in executive programs and advocated for women-leaders to engage in a women-only learning experience at some time in their career. Outcomes of the women-only learning are the source of self-confidence, appreciation of voicing leadership dilemmas, recognition of personal barriers to change, and insight to the gender bias of her professional context. As noted by Debebe (2011), the impetus for a transformative experience comes when women leaders experience the freedom and safety of their first woman-only learning environment (p. 687).

Professional Conversations

Alexandrou, Swaffield & MacBeath (2013) identified professional conversations as the mechanism for leaders to move from their private reflection, to dialogue, and to public exchange in their field of practice. Leaders whose career pathway is in a corporate, health, or government setting are more likely to learn professional conversations as part of in-house training and executive coaching services, or through executive management programs (Hannum, Martineau & Reinelt, 2007; Kets de Vries & Korotov, 2007; Sloan, 2006). The key benefit of executive coaching is an accelerated learning curve for leadership development; and for leaders whose post-secondary education is in education or applied sciences, executive coaching teaches them conversational skills and prepares them for the multi-faceted demands of leading others (Adams, Evangelou, Dia de Figueiredo, Mousoulides, Pawley, Schifellite, Stevens, Svinicki, Trenor, & Wilson, 2011).

Executive coaching is an instructional technique for teaching leaders goal orientation through a conversational mode; it provides a learning space for discovery and transformative experience (De Haan, Bertie, Day & Sills, 2010). Research on coaching for leadership development is substantive in physician and nursing education, education, and psychology, and emerging in women's leadership development (De Haan & Duckworth, 2012; Ely, Ibarra & Kolb, 2011; Garcia, 2009). Joo, Sushko & McLean (2012) defined coaching as a developmental practice for managers, particularly in organizations that moved away from vertical hierarchy to team structures that require leadership for horizontal coordination. Technological change and globalization made engineering more challenging and added complexity to the work processes that did not exist in prior times. As the world of global business formed in the late twentieth century, companies' outsourced work and formed new business alliances that required leaders to sustain alliances through collaboration. Griffiths and Campbell (2009) noted the rapid growth of coaching during the 1990s; Levenson (2009) used case studies to measure the financial benefits of coaching to business; and Bowser (2012) reported that coaching for leadership development contributed to the financial value of the business.

In an organizational context, learning leadership is competency based and the coaching process furthers a culture of organizational learning (Cerni, Curtis & Colmar, 2010). Coaching is interdisciplinary and integrates adult learning, organizational development, counseling psychology, and management education. Joo, Susko & McLean (2012) listed many categories of coaching as managerial coaching, executive coaching, business coaching, life coaching, career counseling, and mentoring. In managerial coaching, coaching integrates process improvement and employee performance and to strengthen the capability of employees. At the managerial level, use of coaching broadens the perspectives of the managers and employees, which helps to accommodate the changing nature of work. All forms of coaching apply facilitated learning with the coach teaching through inquiry, by use of skillful questioning that retains a focus on reaching a solution (Bower, 2012). Usually a face-to-face interaction, the coach guides the leader through a discovery process that opens the way for behavioral change.

De Haan & Duckworth (2012) defined executive coaching as a combination of organization and leadership development; it is based on positive psychology, has a goal orientation, and learning takes place in the cognitive and affective domains. They summarized the outcome research on executive coaching and cited studies where the clients of executive coaches reported productivity gains and increased leadership effectiveness (Bowles, Cunningham, De La Rosa & Picano, 2007; Thach, 2002; Perkins, 2009). Executive coaching utilizes experiential learning, as the leader commits to accomplishing goals and reporting on success; it provides a way for the leader to understand her learning preferences and adapt to a wider range of leader behaviors, including relationship building with followers, peers, and stakeholders (Griffiths & Campbell, 2009; Turesky & Gallagher, 2011). Other studies on outcome research for executive coaching showed increased self-efficacy in goal-setting, more belief in self, increased ratings on feedback from direct reports, and the ability to ask superiors for improvements (Bower 2012; De Hann, Duckworth, Birch & Jones, 2013).

Community of Leaders

Learning leadership necessitates a community of practice where leaders converse and share what they learned in their actions as leaders. Community of practice is metaphor for a learning process that is socially constructed, interactive, and conversational (Nixon & Brown, 2013). The intent is to open a learning space that enables engineer-leaders to share tacit knowledge and move towards a vision of leadership for women in the profession. Key stakeholders include leaders from engineering firms, technology employers, university engineering faculty, licensing agencies, and affiliated engineering and STEM societies. Coordination of formal and informal learning takes place through networking, mentoring, coaching, and learning conversations (Alexandrou, Swaffield & MacBeath, 2013; Debebe, 2011). The purpose of this community is to create a culture of leadership for professionals to articulate, share, and learn leadership. Canadian engineers engage in vibrant communities for their engineering specializations with coordination done through the licensing agencies, university affiliations, and societies (APEGBC, 2010). Building on this existing capacity for shared learning, the leaders begin an incremental movement to define the most relevant dimensions and context for this population of women engineer leaders (Fairman & Mackenzie, 2014; Rowe, Heykoop, & Etamnski, 2015).

Dinpolfo, Silva & Carter (2012) reinforced the proactive responsibilities of senior leaders to develop leaders by investing time to sponsor and promote inclusive leadership development. Like the intricacies of management education versus leadership education, leadership development requires a combination of learning that is transformational, contextual, and experiential. As noted by Garcia (2009), the leader's thinking is incomplete unless it incorporates dialogue and reflection with others. Leaders require a practice field for shared reflection, experience, and deliberate learning. In the organizational context, Garcia's (2009) approach relates to a wider range of issues specific to the organization's culture and its social responsibility. As noted

The profession of engineering bears similarities to that of teaching in the context that leading is secondary to a passion for her engineering practice. Elementary to the growth of an engineer's practice is curiosity, desire for learning, and growth through shared experience that is already evident in the profession.

When leaders are provided with facilitated learning processes, learning is generative and peer coaching emerges as they access and share tacit knowledge (Thomas & Carnall, 2008; Kets de Vries & Korotov, 2007). The motivation to sustain a community comes from their mutual interest in growth as leaders (Debebe, 2011). Equally important to a leader's development is continuous learning and support that is relevant and specific to the leader's profession (Alexandrou, Swaffield & MacBeth, 2013; Reeve, 2010). Learning leadership requires a scaffold of the formal and informal education that provides transformative learning. Formal leadership education is an organized program of learning activities within the physical or virtual environment of an accredited educational institution. In contrast, informal education takes place in the workplace, in client-or customer related situations, and in personal environments (Barakett & Cleghorn, 2000). For engineers in private practice they rely on the infrastructure of the licensing agencies, technical associations and affiliated societies for their professional development.

In conclusion, this paper builds on the research in leadership and management along with the engineering education and curriculum development. I propose a conceptual framework for teaching and learning leadership that provides a foundation for educational programs related to university and professional development for Canadian women engineers.

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