Available online at https://asric.africa/engineering-sciences
ASRIC Journal on Engineering Sciences Vol.4(2)(2024) 104-113

Innovative Engineering Leadership: A Tool to Reform Engineering Education

Mudasiru Bola J..[1, 2]; Nwadike Jones[1, 2]

[1]Nigerian Institution of Highway and Transportation Engineers (NIHTE)
[2]nigerian Institution of Civil Engineers (NICE)

Corresponding Authors' e-mail:
mubola02@iyahoo.com (Mudasiru Bola J.)
japavisca@yahoo.com (Nwadike Jones)

Received 17 April 2024; revised 16 May 2024; accepted 10 June 2024

Abstract

This study delineates the constraints impeding the actualization of robust practical engineering education goals, pivotal for fostering innovation engineering leadership. It scrutinizes the efficacy and impact of assets and service it delivers (the product), alongside the exploitation prospects during operational phases (the process). A comprehensive interpretation of 'innovative engineering leadership' is employed, encompassing the orchestration of engineering teams and technical staff through the entire project life-cycle - from conception, design, execution to operationalization – culminating in corporate triumph. The discourse posits that innovative engineering leadership is instrumental in advancing practical engineering education targets aligned with innovative leadership paradigms. Nonetheless, these targets must be explicitly articulated within the engineering education reform agenda, bolstering processes, products and services to meet an array of stipulations, adhering to budgetary constraints, scheduled timeliness and managing risks judiciously, thereby paving the path for sustainable development.

Keywords: Innovative engineering leadership, product, process, reform engineering education, development.

Introduction

This paper presents the outcomes of a comprehensive investigation into the impediments hindering the realization of enhanced practical engineering education objectives. Notwithstanding the pervasive acknowledgment of the necessity for innovative leadership competencies in engineering graduates, a profound lack of clarity and consensus persists regarding the conceptualization and definition of 'innovative engineering leadership'. To address this knowledge gap, the study operationalized a nuanced and expansive definition of 'innovative engineering leadership', encompassing:

1. Strategic leadership and oversight of multidisciplinary teams comprising engineers, innovators, and technical specialists
2. Comprehensive project life-cycle management, spanning:
   - Conceptualization and ideation
   - Design and development
   - Implementation and deployment
   - Operation and maintenance
3. Integration of technical, business, and organizational acumen to drive innovation and business success
4. Effective communication, stakeholder management, and collaboration
5. Proactive identification, assessment, and mitigation of technical, organizational, and project-related risks.

Innovative Engineering Leadership is a style of leadership based upon the concept of working co-operatively to develop innovative and intuitive ideas (Mumford et al, 2002). Why is creativity important to

engineering and engineering education? The value that creativity and innovation offer lies in their ability to facilitate the development of novel and effective innovative technological solutions to problems stimulated by change (David H Cropley, 2015). Those who employ Innovative Engineering Leaders tend to do so by creating conditions which promote creativity and innovation. Creating such conditions, which are sometimes called "supportive contributions" (Mainemelis et al, 2015), are described as psychological, material, and / or social supports (operations) that trigger, enable and sustain innovative thinking in others (Mainemelis et al, 2015). The term Innovative Engineering Leadership is commonly used in organizational studies and was first referenced in 1957 (Selznick, 1984). In recent years, there has been a significant increase in research surrounding innovative and innovation leadership (Dinh et al, 2014) and the term has also been used increasingly among engineering practitioners (Nikravan, 2012) and in the public sphere (Chernin, 2002). Researchers and engineering practitioners have suggested that Innovative Engineering Leadership is more important in the current political and economic climate than ever before (Sternberg, 2007). It has also been suggested that innovative engineering leaders display behaviours that may contradict traditional management styles (Hunter et al, 2011).

To mitigate this challenge, the paper undertakes a comprehensive examination of the asset's performance and the service it delivers, as well as the opportunities for optimization during operational processes. Furthermore, the paper emphasizes the imperative for engineering students to acquire a holistic understanding of the interconnectedness of physical, life, and information sciences across various scales, including nano-, meso-, micro-, and macro-levels. Additionally, the paper highlights the necessity for engineering students to:

- Integrate professional ethics and social responsibility into their practice
- Cultivate innovative thinking and problem-solving skills
- Develop effective written and verbal communication skills

By addressing these key areas, the paper aims to inform the development of comprehensive engineering education programs that equip students with the requisite knowledge, skills, and competencies to excel in an increasingly complex and interconnected world.

Our students should be prepared to live and work as global citizens, understand how engineers contribute to society. They must develop a basic understanding of business processes; be adept at product development and high-quality manufacturing; and know how to conceive, design, implement and operate complex engineering systems of appropriate complexity. They must increasingly do this within a framework of sustainable development, and be prepared to live and work as global citizens. That is a tall order ... perhaps even an impossible order (Rethinking Engineering Education: The CDIO Approach). Engineering leadership development programs have become increasingly popular as there is a recognized demand for engineers who are well-rounded and possess leadership attributes (Klassen et al, 2016).

The paper concludes that innovative engineering leadership has the potential to promote practical engineering education objectives of organization. However, the objectives should be clearly identified in the reform of engineering education and also support processes, products and services to a set of requirements, within budget, and to a schedule with acceptable levels of risk in the new way for sustainable development. Innovative engineering leadership is a growing field of research with a lack of clarity and limited synchronicity. Education institutions and industry organizations looking to design or revamp innovative engineering leadership programs can also use this definition to provide guidance on the vision and goals of their programs.

Innovative engineering leaders develops mechanisms for effective conflict resolution, encouragement of interaction and information exchange among group members, and fostering cooperation in performing collective tasks (Shin et al, 2007 and Vera et al, 2004).
Taken together, innovative engineering leaders may facilitate the establishment of a strong work group innovative identity by developing group capability to effectively use its members' diverse expertise, while also searching for new and better ways of completing group work.

Aims/Objectives of the Study

The primary objectives of this initiative are to cultivate and empower a multidisciplinary team of engineers and innovators who can effectively lead and navigate all stages of the project life-cycle, encompassing: conceptualization and ideation, design and development, implementation and deployment, and operation and maintenance

Scope and Limitations of the Work

This work evaluates engineering education in innovative engineering leadership. The work is focused on innovative engineering leadership in organizations. In the competencies study, the work focuses on the transversal innovative engineering leadership competencies that engineers should have at graduation cycle (Bachelor) degrees. The wide scope of this work does not allow us to analyze the effect of all possible independent variables.

Statement of the Problems

Is innovative engineering leadership a mysterious gift? A unique talent? A trait? An ability? An attitude? Is it innate, or can it be learned and taught? Does it develop spontaneously? Or is it always present in some individuals? Clearly, some people are more innovative than others. Is this due to the way they think? How they see the world? Or how they react to it? Are certain thought processes, attitudes or beliefs associated with innovative production? If so, perhaps anyone can learn to be more innovative (Larry G. Richards and Robyn Paul).

Today, almost all organizations are facing a dynamic environment characterized by rapid technological change, shortening product life cycles, and globalization. Organizations, especially technologically-driven ones, need to be more innovative and innovative than before to survive, to compete, to grow, and to lead (Jung et al, 2003 and Tierney et al, 1999).

Justification / Significance of the Study

Little research is known to have been undertaken on the innovative engineering leadership, as a viable tool for engineering education reform. A study like the current one undertaken is therefore timely as it examined the viability, profitability or otherwise and economic development in the study area.

The role of innovative engineering leadership in creating (conceiving), designing, initiating and operating (even in trade, manufacture, commerce and agriculture) cannot be swept under the carpet because it embraces leading a group of engineers and innovative personnel in all stages of project life towards business success in organization

Research Methodology and Organization of the Study

The study adopts exploratory method of research that examined and discussed relevant issues of interest in the history of innovative engineering leadership as a viable tool for engineering education reform. Thus, the paper reviews existing literature on innovative engineering leadership. Because of the nature of the study (macro), the writer relies on published documents in the area of innovative engineering leadership using commissioned studies, non-commissioned studies and published works from various sources. Some of these secondary sources are narrow in perspective and scope, but they serve as useful materials for researchers wanting to embark on a macro-study.

The study is organized in six (6) sections, apart from the introduction, aims and objectives, scope and limitations of the study, statement of the problem, justification of the study and research methodology and organization of study. These are: - summary of definitions found in literature, review of literature, innovative engineering leadership mainstream, characteristics of successful innovative engineering leadership, conclusion and references.

Research Hypotheses

To aid the completion of the study, the following research hypotheses were formulated by the researchers.

H0: there is no positive effect of innovative engineering leadership in effective functioning of the engineering education.

H1: there is a positive effect of innovative engineering leadership in effective functioning of the engineering education.

Summary of Definitions Found in Literature

What is Creativity?

Is Creativity a mysterious gift? A unique talent? A trait? An ability? An attitude? Is it innate, or can it be learned and taught? Does it develop spontaneously? Or is it always present in some individuals? Clearly, some people are more innovative than others. Is this due to the way they think? How they see the world? Or how they react to it? Are certain thought processes, attitudes or beliefs associated with innovative production? If so, perhaps anyone can learn to be more innovative (Larry G. Richards and Robyn Paul).

Creativity is a phenomenon whereby something new and somehow valuable is formed. The created item may be intangible, such as an idea, a scientific theory, a musical composition, or a joke or a physical object, such as an invention, a printed literary work, or a painting (Creativity – wikipedia.html).

What is Leadership?

Leadership is organizing and directing the efforts of a group. In a broad sense, leadership is creating (developing) and organizing (engaging) others in a common vision, clearly planning and organizing resources, developing and maintaining trust, sharing perspectives, inspiring creativity, heightening motivation, and being sensitive to competing needs. Leadership is the art and science of influencing others toward accomplishing common goals and does not necessarily require a formal role or position within a group (Robyn Paul, 2018).

What is Engineering Leadership?

Engineering Leadership is the ability to lead a group of engineers and technical personnel responsible for creating, designing, developing, implementing, and evaluating products, systems, or services.

Innovative Engineering Leader

The idea of innovative engineering leadership started with James McGregor Burns approximately three decades ago (Burns, 1978). The innovative engineering leader has been characterized as one who articulates a positive vision of the future that can be shared with subordinates and among peers, pays high attention to diversity and intellectually stimulates sub-ordinates to perform beyond what they think is possible for them (Bass et al, 1990).

What is Innovative Engineering Leadership?

Innovative Engineering Leadership is the process of creating (envisioning), designing, initiating (developing), and organizing (supporting) new products and services to a set of requirements, within budget and to a schedule with acceptable levels of risk to support the strategic objectives of an organization." Note: This paper focused on engineering management, but the tone is very much towards teaching engineering management to "engage innovative engineering leadership towards business success" therefore the definition was included.

Numerous researchers have used the term Innovative Engineering Leadership since it was first used as a concept in the 1950s. The meanings may differ across research contexts (Mainemelis Charalampos Ronit Kark et al, 2015).

More views on the definition and scope of Innovative Engineering Leadership include: - Leading others toward the attainment of an innovative outcome (Mainemelis Charalampos Ronit Kark et al, 2015). - Deliberately engaging one's imagination to define and guide a group toward a novel goal-a direction that is new for the group (Puccio G., et al, 2011). - An imaginative and thought-through response to opportunities and to challenging issues that inhibit learning at all levels. It is about seeing, thinking and doing things

differently in order to improve the life chances of all students. Innovative leaders also provide the conditions, environment and opportunities for others to be innovative (Stoll L., et al, 2009). An innovative engineering leader induces others to focus the process and process education on meeting their challenges. They become consultants or facilitators in the process of solving the challenge rather than giving orders or doing the work themselves. Having transferred ownership, they then help others to achieve their own goals. These Innovative Engineering Leadership education hardly fit with the traditional management style that most organizations employ, but they can be learned (Mumford M. D., et al, 2002).

Literature Review

A review of the literature related to these programs show that they aim to provide professional education such as creativity, communication, innovation, execution, personal drive and teamwork (Robyn Paul et al, 2015). National engineering bodies have also recognized this need to educate engineers in innovative engineering leadership. In the report entitled "The Engineer of 2020", innovative leadership was one of the key attributes mentioned (National Academy of Engineering, 2005, p. 53).

Conceive-Design-Implement-Operate (CDIO), an innovative educational framework for engineering, also addresses the need for innovative engineering leadership in their most recent syllabus update (E. F. Crawley et al, 2014, p. 69).

The Canadian book, Fundamental Competencies for the 21st Century Engineers, has also recognized this need, and has added innovative leadership as an essential competency for engineers in their most recent edition (A. B. Dunwoody et al, 2018).

The attribute of leadership has also been included in the new student outcomes for ABET (Accreditation Board for Engineering and Technology), which has become effective in the 2019 - 2020 accreditation cycle (replacing the "a-k" outcomes). Students must be able to "function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" (ABET, 2017, p. 40).

Interest is growing in the influence of innovative engineering leadership on creativity and innovation. Innovative engineering leaders raise the performance expectations of their followers (Bass, 1995) and seek to transform followers' personal values and self-concepts and move them to higher level of needs and aspirations" (Jung, 2001).

There are several possible mechanisms through which innovative engineering leadership may enhance employee individual creativity. For example, innovative engineering leaders encourage followers to challenge the status quo and experiment with new and different approaches to their work (i.e., intellectual stimulation; Bass et al., 2003). First, innovative engineering leaders challenge followers thoughts and imaginations, recognize their innovative values, beliefs, and mind-set, develop individual employees and work teams' capabilities, provide resources and support and give them discretion to act, and energize followers to work harder toward achieving higher targets (Bass, 1985), all of which could help develop followers' self-views of being innovative. Innovative engineering leaders also create new learning opportunities for followers to grow, give followers discretion to act, and show appreciation and support of followers individual consideration (Bass et al., 2003).

Innovative engineering leaders develops mechanisms for effective conflict resolution, encouragement of interaction and information exchange among group members, and fostering cooperation in performing collective tasks (Shin et al, 2007 and Vera et al, 2004).

Taken together, innovative engineering leaders may facilitate the establishment of a strong work group innovative identity by developing group capability to effectively use its members' diverse expertise, while also searching for new and better ways of completing group work.

Innovative engineering leaders encourage followers to challenge the status quo and to solve problems by trying out new approaches. Furthermore, they appreciate followers" ideas even if they are different from the traditional way of thinking (Sharma et al., 2012 and Çekmecelioğlu et al, 2016). They frequently

emphasize the value of novel ideas and thus followers feel comfortable in proposing new alternatives or even taking risks (Shin et al, 2003 and Çekmecelioğlu et al, 2016).

(Rowold et al, 2007), innovative engineering leadership has been studied extensively; several studies have reported that the innovative engineering leadership style has been associated with numerous variables, such as organizational learning (Mirkamali et al, 2011); employee effectiveness (Srithongrung, 2011); innovative flexibility (Sharma et al, 2012); communication competency (Çetin et al, 2012); leadership effectiveness (Zhang et al., 2012); and employees' job satisfaction (Munir et al, 2012).

Only very few empirical studies have focused on the relationship between innovative engineering leadership and crisis management, such as Hasan et al, 2017, who examined the association between leadership styles and crisis management in the Ministry of Planning in Erbil, Iraq; the findings reveal that innovative engineering leaders can predict crisis management.

Innovative Engineering Leadership Mainstream Competencies

According to Stoll and Temperley, 2009, 69–74, innovative engineering leaders foster conditions that can help to inspire creativity in others. These conditions include: - stimulating a sense of urgency if necessary, exposing colleagues to new thinking and experiences, providing time and space to facilitate the practicalities; - setting high expectations, promoting individual and collaborative innovative thinking and design, using failure as a learning opportunity, relinquishing control and the modelling of creativity and risk-taking (Stoll L., et al, 2009). - Ball, 2015, suggests that the five (5) core competencies for Innovative Engineering Leadership are: - acting with passion and purpose, - applying an explorative mindset, - envisioning a better future, -orchestrating innovative teams, and - driving breakthrough change (Ball Rajiv, 2017).

Sohmen's, 2015, research argues that good innovative leaders consistently develop the following characteristics in themselves: - leadership styles and perceptions, - understanding of different cultures, - individual and team motivations, - interpersonal education, - levels of creativity, - ability to manage change, -communication styles, - listening ability, - decision-making education, and - personal ethics (Sohmen V., 2015).

Conceptualizations

Three different complementary conceptualizations have been suggested which reflect the different contexts in which Innovative Engineering Leadership can be applied: - facilitating creativity - directing an innovative vision, and - integrating diverse innovative contributions (Mainemelis et al, 2015). Innovative Engineering Leadership may be enacted differently depending on the context.

Facilitating

In the context of facilitating, those who employ Innovative Engineering Leadership will support employees or individuals as primary creators, influencing their innovative contributions and shaping each stage of the innovative process. In the context of facilitating, innovative leaders lead in a way that increases employees' likelihood of generating new ideas (Mumford, et al, 2002). As facilitators, innovative leaders foster others' creativity and may take individuals through a process that helps them generate new ideas, such as brainstorming (Rickards, et al, 2000 and Basadur, 2004). In the context of facilitating, those who employ Innovative Engineering Leadership are involved in the entire innovative process and shape a supportive climate for creativity (Mumford, et al, 2002).

Directing

In the context of directing, those who employ Innovative Engineering Leadership are the primary creators and their vision is enacted through contribution and collaboration from others (Mumford M. D., et al, 2002). Mumford, Scott, Gadis and Strange (2002) suggest that, in directing, a leader is integral to the production of an innovative concept, while others support its implementation. The degree to which others contribute innovatively may depend upon the situation. This can be compared to an orchestra conductor, who provides

a vision and direction for musicians who bring their own individual contributions (Basadur M., 2004). A strong directive innovative leader may inspire, elicit, and integrate high-quality contributions from his or her collaborators (Mumford M. D., et al, 2002).

Integrating

In the context of integrating, there is a focus on the innovative leader's ability to integrate or synthesize his or her novel ideas with various innovative ideas from other individuals (Mumford M. D., et al, 2002). Compared to directing and facilitating contexts, there is a greater balance between the ratio of leader to follower innovative contributions and supportive contributions in the integrating context. Each individual can receive credit for their distinct contribution, and successful leadership in this context depends on the leader's ability to synthesize others' innovative inputs. Film directors are an example of leaders working in an integrating context, providing guidance to create a feature film that includes innovative contributions from numerous people: screenwriters, actors, special effects technicians, costume designers, etc. (Simonton, D. K., 2002).

As societies rapidly advance, and populations grow to unprecedented levels, engineering leaders are faced with solving increasingly complex problems of a magnitude not previously seen. Solving these problems will require more than just the innovative and innovative abilities that have traditionally been taught in engineering education programs. Rather, engineering leaders of the future will be required to possess key non-technical attributes which enable them to also understand and navigate social, political, economic, cultural, environmental, and ethical aspects of the innovative projects on which they are working (ASME, "2008). Engineering educators must meet the challenge of providing their students with professional attributes and essential critical thinking education to create the engineering leaders and innovators of tomorrow (D. J. Bayless et al, 2010).

Characteristics of Successful Innovative Engineering Leaders

Characteristics of success that Innovative Engineering Leaders share, including independence, generosity, purposefulness, and optimism. Innovative Engineering Leadership is not industry specific, nor is it one-size-fits all. It is the individual act of a leader in the context of perpetual beta, and therefore path-dependent. In contrast to analytical forms of leadership, where the act of problem-solving culminates in one truth, Innovative Engineering Leadership presupposes that the drive for a solution to a problem or challenge can have several outcomes and is to a significant degree shaped by the leader.

Although Innovative Engineering Leadership is not exclusive to entrepreneurs, Innovative Engineering Leaders display many elements of entrepreneurial behavior. These are: -

- Innovative Engineering Leaders empower their organizations by nurturing and cherishing the ideas of others.

- Innovative Engineering Leaders live in perpetual beta, they are never satisfied with the first solution. Innovative Engineering Leaders create urgency and shared inevitability to work towards a better future for all, thereby inspiring others to act. They dare to be bold in new areas, not limited by present logic or institutions, embracing fears rather than avoiding them.

- Innovative Engineering Leaders think globally, strategically and towards the large impact. They understand how to mitigate risks, with a head in the clouds and feet firmly on the ground. They are able to master execution in uncharted territory with imperfect information and limited control. They maintain focus towards longer-term social impact, while being resourceful in capturing opportunities as these arise and overcoming challenges to keep the enterprise afloat. They are good stewards of natural and manmade resources.

- Casting and conducting of Innovative Teams, Cultivating Courage, and Optimistic Experiment.
- Innovative Engineering Leaders are able to master execution in uncharted territory.
- Innovative Engineering Leaders think big visionary, logically and globally, strategically and towards large impact with social passion and generous purpose. They have social awareness and holistic connectedness. They exhibit mindful self-awareness, being connected to what is happening in the here and now,

demonstrate compassion for others, and exude a humble, open attitude. They are able to translate an appealing market opportunity into an enterprise concept that is innovative against incumbent business models. They can integrate large society al impact with attractive economic returns.

Innovative Engineering Leaders are able to attract team members who raise the calibre and diversity of the collective. They are capable of designing innovative processes that enable learning and improvement resulting in an accelerating rate of improvement, working toward a tipping point where change becomes unstoppable. Successful innovative engineering leaders pay meticulous attention to the smallest of details. For a successful innovative engineering leaders, communication means the ability to not only understand technical complexities, but the ability to succinctly and effectively translate technical jargon into layman's terms without patronizing others.

Any project, no matter how big or small, will face problems. Successful innovative engineering leaders must be able to effectively address these as they arise. Technology and methodologies are constantly changing. Staying up to date with the latest developments puts Innovative Engineering Leaders ahead of the field.

They know what key values are important in one's life and act authentically upon them. They are transparent and honest, with congruence between intentions, words, presence, and actions. They build an organizational culture that nurtures and cherishes the ideas of others, removes barriers and structures incentives to reinforce the change that is being sought. They provide the story, experiences, and motivations that empower the organization toward a common goal. They orchestrate the ecosystem of partners in the public, private and social sector to bring systemic change.

Conclusion

The paper concludes that innovative engineering leadership has the potential to promote practical engineering education objectives of organization. However, the objectives should be clearly identified in the reform of engineering education and also support processes, products and services to a set of requirements, within budget, and to a schedule with acceptable levels of risk in the new way for sustainable development. Innovative engineering leadership is a growing field of research with a lack of clarity and limited synchronicity. This proposed definition provides a foundation for a clear understanding of the what, the how, who and the why of innovative engineering leadership. Education institutions and industry organizations looking to design or revamp innovative engineering leadership programs can also use this definition to provide guidance on the vision and goals of their programs. Engineering and students must be able to "function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" (ABET, 2017, p. 40).

Innovative engineering leaders develops mechanisms for effective conflict resolution, encouragement of interaction and information exchange among group members, and fostering cooperation in performing collective tasks (Shin et al, 2007 and Vera et al, 2004). Taken together, innovative engineering leaders may facilitate the establishment of a strong work group innovative identity by developing group capability to effectively use its members' diverse expertise, while also searching for new and better ways of completing group work.

References

A. B. Dunwoody et al, Fundamental Competencies for the 21st-Century Engineer, 2nd ed. Oxford University Press, 2018.

ABET, "Criteria for Accrediting Engineering Programs: Effective for Reviews During the 2018-2019 Accreditation Cycle," Baltimore, MD, 2017.

Aldert Kamp, Engineering Education in the Rapidly Changing World Subtitle: Rethinking the Vision for Higher Engineering Education, 2nd Revised Edition, Delft, Netherlands, 2016.

Ali Idris et al, The Trend of Engineering Education in Nigerian Tertiary Institutions of Learning towards achieving Technological Development, Malaysia, 2012.

Alison Doyle, Innovative Thinking Definition, Education, and Examples, 2019.

ASME, "2028 Vision for Mechanical Engineering: A report of the Global Summit on the Future of Mechanical Engineering," New York, 2008.

Corcoran, P.B. et al, Higher Education and the Challenge of Sustainability: Problematics, Promise, and Practice, 353 p. ISBN 1402020260, New York: Kluwer Academic Publishers, 2004.
B. J. Novoselich and D. Knight, "Developing engineers who lead: Are student, faculty and administrator perspectives aligned?" in American Society for Engineering Education (ASEE) Annual Conference and Exposition, 2014.
Ball Rajiv, The Paradoxes of Innovative Leadership, Innovation Management, 7 Aug., 2015, http://www.innovationmanagement.se/2015/07/08/cl-the-paradoxes-of-innovative-leadership/, 2017.
Basadur M. et al, Where are the generators? Psychology of Aesthetics, Creativity, and the Arts, 5, 29–42, 2011.
Basadur, Min., Leading Others to Think Innovatively Together: Innovative Leadership, 2004.
Chernin, Peter, Innovative Leadership. Vital Speeches of the Day, vol. 68, no. 8, 2/1/2002, p. 245. EBSCOhost, 2002.
D. B. Knight et al, Curricular and Co-curricular Influences on Undergraduate Engineering Student Leadership, J. Eng. Educ., vol. 106, no. 1, pp. 44– 70, 2017.
D. J. Bayless et al, Leadership Education for Engineering Students, in ASEE/IEEE Frontiers in Education Conference, 2010.
David Cropley, Promoting Creativity and Innovation in Engineering Education, David H Cropley, Australia, 2015.
Delaine D. A. et al, Global Diversity and Inclusion in Engineering Education: Developing Platforms toward Global Alignment. http://dx.doi.org/10.3991/ijep.v6i1.5372, USA, 2106.
Dinh J. E. et al, Leadership theory and research in the new millennium: Current theoretical trends and changing perspectives. Leadership Quarterly, 25, 36–62, 2014.
E. F. Crawley et al, Rethinking Engineering Education, 2014.
Edward F. Crawley et al, Rethinking Engineering Education. The Conceive-Design-Implement-Operate {CDIO} Approach), USA, 2007.
Fredricka K. Reisman, et al, Creativity and Innovation in STEM Education, 2019 International Conference on Knowledge, Innovation and Enterprise, Dubai, UAE.
Heather Fry et al, A Handbook for Teaching and Learning in Higher Education. Enhancing Academic Practice, Third edition, UK, 2009.
Hunter S. T. et al, Paradoxes of leading innovative behaviors: Summary, solutions and future directions. Psychology of Aesthetics, Creativity, and the Arts, 5, 54–66, 2011. https://en.wikipedia.org/wiki/21st_century_education.
Ian de Vere, Developing Innovative Engineers: A Design Approach to Engineering Education, Australia.
Iouri Belski et al, Educating an Innovative Engineer: Learning from Engineering Professionals, Munich, Germany, 2016.
Isam Zabalawi, Engineering Education for Future World: The CDIO Approach (Conceive, Design, Implement, Operate), Muscat, 2018.
Jonathan Harwood, Engineering Education between Science and Practice: Rethinking the Historiography, 2006.
Jordi Segalàs Coral, Engineering Education for a Sustainable Future, Barcelona, 2009.
Lakshminarayanan Samavedham et al, Facilitating 21st century education in engineering students, Journal of Engineering Education, Vol. xxv1, No. 1, Singapore, January 2008.
Larry G. Richards, Stimulating Creativity: Teaching Engineers to be Innovators, Virginia.
M. Klassen et al, "Charting the Landscape of Engineering Leadership Education in North American Universities," in American Society for Engineering Education (ASEE) Annual Conference and Exposition, 2016.
Mumford M. D., et al, Leading innovative people: Orchestrating expertise and relationships. Leadership Quarterly, 2002.
Mainemelis Charalampos et al, Innovative Leadership: A Multi-Context Conceptualization, 2015.
Puccio G., et al, Innovative leadership: Education that drive change (2nd ed.). Thousand Oaks, CA: Sage Publications, 2011.
Mainemelis Charalampos, et al, Innovative Leadership: A Multi-Context Conceptualization. The Academy of Management Annals 9.1: 393-482, 2015.
Márcia Longen Zind et al, A New Approach in Engineering Education : The Design-Centric Curriculum at the University of Brasília-Brazil, 2012.
Martin Erro A., Creativity and Engineering Education: A Survey of Approaches and current State, Spain, 2016.
Mumford M. D. et al, Leading innovative people: Orchestrating expertise and relationships. Leadership Quarterly, 13, 705–750, 2002.
Mahmoud Abdulwahed et al, The Role of Engineering Design in Technological and 21st Century Competencies Capacity Building: Comparative Case Study in the Middle East, Asia, and Europe.
Melissa T. Greene et al, Design Thinking vs. Systems Thinking for Engineering Design: What's the Difference? Manuscript for 21st International Conference on Engineering Design, Vancouver, Canada, 2017.

Mueller, J. S., et al, Recognizing innovative leadership: Can innovative idea expression negatively relate to perceptions of leadership potential? Journal of Experimental Social Psychology, 47, 494–498, 2011.
National Academy of Engineering, the Engineer of 2020: Visions of Engineering in the New Century, Washington, D.C.: National Academies Press, 2005.
Nikravan L., Why creativity is the most important leadership quality. Chief Learning Officer. Retrieved from http://www.clomedia.com/articles/why-creativity-is-themost-important-leadership-quality, 2012.
Nwadike J., et al, Creative engineering leadership: A tool to reform engineering education, Nigeria, 2020.
Nwadike J., et al, A chance to advance Nigeria's success through Digital Technologies: How authentic? Nigeria, 2023.
Oloyede A. A. et al, Embracing the Future of Engineering Education in Nigeria: Teaching and Learning Challenges, Nigerian Journal of Technology (NIJOTECH), Nigeria, Vol. 36, No. 4, October 2017,
Pankaj Sharma et al, Impact of Innovative engineering Leadership on Innovative Flexibility of Engineers in India, 2012.
Rickards T., et al, Innovative leadership processes in project team development: An alternative to Tuckman's stage model, Britain, 2000.
Robyn Paul et al, Engineering leadership education: A review of best practices, in American Society for Engineering Education (ASEE) Annual Conference and Exposition, 2015.
Robyn Paul et al, What is Engineering Leadership? A Proposed Definition, ASEE Annual, 2018.
Sarosh Kuruvilla Adjusting to Globalization through Education Development Strategies, Cornell University ILR School, sck4@cornell.edu, 2007
Robyn Paul, Towards an Understanding of the Influence of Student Leadership Development on Early-Career Engineers, Master's thesis, University of Calgary, 2018.
Selznick, P., Leadership in administration. Berkeley, CA: University of California Press, 1984.
Simonton, D. K., Collaborative aesthetics in the feature film: Cinematic components predicting the differential impact of 2,323 Oscar-nominated movies. Empirical Studies of the Arts, 2002.
Sohmen V., Reflections on innovative leadership. International Journal of Global Business, 8 (1), 1-14, 2015.
Stoll L., et al, Innovative Leadership: A Challenge of Our Times, 2009.
Sternberg R. J., A systems model of leadership: WICS. American Psychologist, 62, 34–42, 2007.
Sylvia Alexander et al, A Handbook for Teaching and Learning in Higher Education. Enhancing Academic Practice Third edition, UK, 2009.
Xisong Dong et al, A Review of Engineering Education in China: History, Present and Future, ASEE International Forum, Columbus Ohio 2017.