

An Integrated Vision of Management and Leadership for Delivering 21st-century Civil Infrastructure

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Abstract

The American Society of Civil Engineers (ASCE), as the recognized leader of the civil engineering profession, has been at the forefront of efforts in delivering 21st-century civil infrastructure. In its Vision 2025 (2006), ASCE stated that this vision for the profession will require civil engineers to be “master leaders in discussions and decisions shaping public environmental and infrastructure policy.” In 2009, ASCE issued a roadmap for achieving this Vision, saying it was necessary to initiate new programs, develop plans, and most importantly, recruit champions for this vision. As of 2021, ASCE has not been successful in fully achieving these outcomes. The paper focuses on a critical part of the Vision 2025 goals - the master leaders of public policy discussions on infrastructure investment and why the 2009 road map did not achieve this goal. It also recommends that ASCE reinvigorate the roadmap effort to develop master leaders by solving three core problems, positioning the profession to be recognized as master leaders, recruiting champions, and creating educational and experiential pathways for future leaders. Solving the latter problem on pathways will involve curricular modifications.

Introduction

In 1995, the Civil Engineering Education Conference (CEEC 95) highlighted the need to expand civil engineers' communication skills, management concepts, teamwork, and leadership skills.

[1] The National Academy of Engineering (NAE) [2] and the American Society of Civil Engineers (ASCE) [3] conceived of civil engineering in the years 2020 (NAE) and 2025 (ASCE) as requiring skillsets beyond the traditional technical competence to include “leadership ability ... “. [4] In 1999, ASCE recognized a lack of leadership education to support the “current prevalent career path of starting from primarily technical work through project management and into management and leadership.” [5] One consequence of this lack of leadership development is that non-engineers often manage civil engineers because they were perceived to possess “... stronger leadership, communication, and business skills”. [5]

In 2006, the American Society of Civil Engineers convened a “Summit on the Future of Civil Engineering” in response to concerns for the civil engineering profession's future and articulated an “aspirational global vision,” the Vision 2025 statement. [3] Part of this vision was for civil engineers to serve “competently, collaboratively, and ethically” as master “leaders in discussions and decisions shaping public environmental and infrastructure policy.” [3] The concept of leadership was deeply embedded in the CE Vision statement. The vision aspired for civil engineers in 2025 was to be recognized as leaders in a wide range of environmental and infrastructure topics [3] and skilled in communicating the crucial link between infrastructure investment and social well-being [3] and supported by a robust educational pathway for civil engineers that prepares them for leadership [3].

Achieving this goal had three significant implications. The civil engineering profession had to be repositioned as effective stewards of scarce economic resources and a force for improving social well-being and economic productivity. Crucially, obtaining the “social license” in increased funding to build public infrastructure. Secondly, the profession’s stakeholders must recognize the validity and compelling nature of the profession’s arguments for the types and funding levels for

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public infrastructure investment. The profession must offer compelling and persuasive arguments for the role that public infrastructure investment plays in increasing the American economy's gross domestic product in the 21st century. The third was that the leadership preparation pathways must recognize the emergence of a dichotomous concept of leadership development, one that recognized the difference in leadership skills that advanced individual careers from those that advanced the profession in the areas of “professional practice, infrastructure, and environment.” [3]

Three years after issuing its vision document in 2006, ASCE produced a roadmap saying it was necessary to initiate new programs, develop plans, and, most importantly, recruit champions to achieve this vision.[6] ASCE acknowledged that no one group could “encompass the full expertise and insight needed” to implement the Vision 2025 document fully. The road map recommended going forward in several areas but emphasized that ...

“It will also be necessary to launch some major new initiatives, find champions, formulate detailed plans, and garner support.” [6]

The purpose of this paper is to focus on a critical part of the Vision 2025 goals - the master leaders of public policy discussions on infrastructure investment and seek to answer the question of why the 2009 road map did not achieve this part (“master leaders”) of the 2006 aspirational goals for the profession. The paper also seeks to make recommendations to the ASCE Committee on Developing Leaders (CDL) to reinvigorate part of the roadmap effort, i.e., to achieve status as master leaders in public policy discussions related to infrastructure delivery. The concept of master leader represents an integration of technical, management, and leadership skills, among others. Achieving status recognition as master leaders in project delivery and public policy discussions requires solving three core problems, positioning the profession to be recognized as master leaders in infrastructure policy discussions, recruiting champions, and creating educational and experiential pathways for future leaders.

Disclaimer: While the authors have various affiliations within ASCE, the observations, conclusions, and recommendations are those of the authors and not necessarily of ASCE. ASCE is currently investigating other aspects of civil engineering leadership and advocacy before determining how best to proceed.

The problem of repositioning the profession as master leaders

To be recognized as master leaders in policy discussions for infrastructure, ASCE and the civil engineering profession must be perceived as a credible source of thinking and ideas on delivering public infrastructure in the 21st century. This paper argues that ASCE’s thinking in 2006, reaffirmed in 2009, was that the Vision and roadmap would be the main focus of the efforts to reposition the profession. This has not been the case as there has been little recognition of the Vision and related road map documentation [6]. However, the Infrastructure Report card has been highly visible in the media and trade publications, and academic journals. A review of these criticisms provides some keen insight into the profession's perception and ASCE’s efforts. To be

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recognized as a more credible source for infrastructure policy, ASCE must address these criticisms, some of which date back to its first report in 1998.

In 1988, the National Council on Public Works Improvement of the Federal government reviewed the condition of America's infrastructure and gave it an overall grade of "C." [7] Unlike the later ASCE reports, the council did not provide additional information on the grading system. The report did note that the then-current spending levels were just sufficient to cover the amount of physical infrastructure "consumed" or used in a year. This physical consumption is the economic depreciation of a capital asset instead of the accounting treatment of depreciation. Economic depreciation distinguishes between "...the value of the stock of capital assets and the annual value of that asset's services, distinguishing between depreciation and inflation as sources of the change in asset value, and distinguishing between the depreciation in asset values and deterioration in an asset's physical productivity." [8] The report stated that as of 1989, this stock of physical infrastructure needed to expand by 30% or more to accommodate forecasted economic growth. Paradoxically, the report qualified its forecasts.

"While a sound infrastructure does not guarantee future prosperity, long-term economic growth cannot be achieved without it. ... infrastructure investment directly supports additional economic activity." [7]

The Federal government chose not to reissue the report. In 1998, ASCE issued its first Infrastructure Report Card based upon the earlier Federal report. [9] One contemporaneous review of the first ASCE Infrastructure Report Card product noted that there were questions to answer before policymakers could "accept the (ASCE) grades as a valid representation of infrastructure performance and a basis of our investment." [9] Price argued that three of the critical variables in the ASCE report, namely capacity, condition, and service level, do not fully convey the impact of report card findings without an equal understanding of service quality and performance expectations. However, a common understanding in our society of infrastructure service levels does not exist, nor do we have a common basis for the investment required to achieve that service level. [9] Civil engineers have a crucial part in infrastructure issues, but they confront significant uncertainties and risks in characterizing existing or new infrastructure capacity.

"The capacity of (infrastructure) is a source of constant debate between engineers, managers, political leadership, and users... (and) ... must ensure that all users agree on the desirable capability. [9]

The problem civil engineering confronts in answering this criticism is how common professional standards and grades address the issues raised. [9] There was also criticism of inconsistent terminology in the report card, one commentator noting the "casual use" of the phrase "infrastructure crisis" in the ASCE report cards and other reports (Wright 1999, citing Everett, 1996). [9]

Thirty years later, the infrastructure discussion has become more focused, and ASCE has performed more in-depth evaluations. Each subsequent release of the Infrastructure Report Card has more discussion of assumptions, additions of specific anecdotes of user impacts, and tangible

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recommendations to improve the Nation's infrastructure. At the same time, economists have continued to research the role infrastructure plays in promoting economic growth measured by gross domestic product growth. Economists now challenge the thinking that infrastructure investment directly supports additional economic activity with the Congressional Research Service (CRS) [10] in its outlook on infrastructure notes that ...

“(W)ith respect to overall economic output, increased infrastructure spending by the government is generally expected to result in higher economic output in the short term by stimulating demand and in the long term by increasing overall productivity. The short-term impact on economic output largely depends on the type of financing (whether deficit financed or deficit neutral) and the state of the economy (whether in a recession or expansion). The long-term impact on economic output is also affected by the method of financing, due to the potential for “crowding out” of private investment when investments are deficit-financed.” [10]

Instead of the 1988 vision of an inextricable linkage between infrastructure investment and economic growth, the 2017 analysis states that in summary:

“The ability for businesses to produce goods and services more efficiently is a crucial determinant of economic growth, and increased infrastructure investment—if well targeted and depending on the degree of crowding out—likely contributes to increased productivity over time, leading to higher GDP; over the long term.” [10]

In 2016, the Congressional Budget Office (CBO), in its report on the macroeconomic effects of Federal infrastructure investment [11], was equally qualified in its comments. The CBO stated that “(t)he increase in productivity that results from federal investment boosts economic output—but only gradually.” The CBO estimated that it would take 20 years for the full potential of Federal investment to “become productive.” [11] As an example of this gradual improvement, CBO found the public infrastructure increased the productivity of the US economy by 5% (\$50 million) of the invested amount each year until it was fully productive. Thus, a one-billion increase in annual investment spending in infrastructure 2021 would increase the private-sector gross domestic output by \$50 million in real dollars each year until 2033, when the entire one billion \$s was realized.[11]

These criticisms of increased infrastructure spending are a direct challenge to the ASCE Infrastructure Report Card. This paper recommends that ASCE evaluate these criticisms and adjust future report cards to better position the profession in a master leader role concerning infrastructure and thus effectively deliver its message.

Research has shown that

“... the development of high-quality institutions is the major factor behind economic growth ... (and) the efficiency of a political jurisdiction's social and economic institutions defines economic development.” [12]

What is most important is the institutions' ability to instill confidence in the future and create predictability and reliability that allow the private and public sectors to make investment decisions. Lastly, institutions that support economic development are a “product of history,

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culture and historical accident.” [12] Setting a goal of specific economic development in terms of total factors of production or physical infrastructure means “building or augmenting existing institutions that are critical to progress.” [12]

As a high-quality institution, ASCE aspires to be a significant factor behind the American domestic economy's economic growth in the 21st century, instilling confidence in the future and creating the predictability and reliability that allows the private and public sectors to make investment decisions. This is simply a restatement of the Vision 2025 goal of repositioning the profession to be recognized as master leaders in infrastructure policy discussion. Nevertheless, it is a more powerful statement in that it provides the rationale for the shift in thinking about ASCE and the civil engineering profession. Society acknowledges ASCE because of its confidence in its thinking and ideas and civil engineering's ability to deliver infrastructure reliably and predictably. This is missing in the 2009 roadmap but should be part of rethinking or reimagining Vision 2050 versus Vision 2025.

The problem of recruiting champions

As an institution supporting economic development in the 21st century, ASCE is very much a product of history and culture. Implicitly, Vision 2025, or a potential Vision 2050, means growing or augmenting ASCE's institutional capacity is critical to American society's progress in the 21st century. ASCE and the civil engineering profession must be perceived as a credible source of thinking and ideas on delivering public infrastructure in the 21st century and equally capable of achieving large-scale changes in infrastructure policy.

This paper argues that the role master leaders play in these infrastructure policies requires civil engineers to influence policy, either directly or indirectly, which is civil engineering advocacy. Advocacy, in this sense, is the attempt to influence public policy at any level, directly or indirectly. This effort can take place either singularly (such as ASCE's Infrastructure Report Card) or in coalitions (such as the “International Coalition for Sustainable Infrastructure (ICSI) [13]” and “BuildStrong Coalition.”). Civil engineering advocacy can change the dynamics of public policy through civil engineering expertise, respect, and influence that an institution like ASCE and its membership commands.

To accomplish this, civil engineering advocacy must be seen as credible and reliable for certain things, such as substantive expertise on American infrastructure. While civil engineering advocacy possesses the requisite substantive expertise to establish credibility, its goal is to generate an equally important element of passion in its membership. Passion is a strength that is endemic to the successful civil engineering advocate and an indicator of engaged membership. Master leaders are champions who engage in advocacy to effectuate infrastructure policy change and achieve recognition as master leaders of public policy discussions. The Vision 2025 document also visualized ASCE as obtaining “social licenses” from civil society and government regulators to deliver infrastructure.[3] Social licenses were the primary vehicle for achieving large-scale policy changes. As ASCE's experience in achieving its Vision 2025 demonstrates,

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social licenses do not affect large-scale change. As other advocacy organizations have demonstrated, large-scale policy change requires social capital.

“social capital refers to the processes between people which establish networks, norms, social trust, and facilitate coordination and cooperation for mutual benefit. These processes are also known as social fabric ... “ [14]

Social capital has many different forms, and it may be public or private. For civil engineering, public forms address public issues such as infrastructure policy. Similarly, it may be formal or informal. However, for ASCE, social capital means long-term involvement by its membership and their willingness to be a part of a dues-paying organization. Lastly, bonding links civil engineers into networks with a dense fabric of professionals with strong ties as another form of social capital.[14]

“Social capital refers to those stocks of social trust, norms, and networks that people can draw upon to solve common problems.” [14]

Professional associations such as ASCE can generate significant amounts of social capital, and the density of its network means that its members cooperate for mutual benefit. Accumulating social capital produces the economic benefits necessary for infrastructure policy change. [14]

“Like other forms of capital, social capital is productive, making possible the achievement, of certain ends that would not be attainable in its absence ...” [14]

Trust in ASCE leaders and ASCE as an institution itself by its members and society is essential for the level of engagement needed to develop the social capital necessary to effectuate infrastructure policy change. Creating such a large-scale policy change for infrastructure requires “continuous and deepening levels” of engagement on the issues. [15] Again, as ASCE’s experience with its Vision 2025 demonstrates, such initiatives can lose momentum, even perish if ASCE cannot generate and sustain an engaged membership and recruit champions. [15]

Achieving large-scale changes in infrastructure policy with civil engineering champions requires ASCE to solve three more subsidiary problems; first, engaging its membership[16] to deepen the pool of leaders in ASCE membership; secondly, repositioning the profession to focus on building social capital, not social licenses and lastly, achieving “critical mass,” i.e., mobilizing a sufficient number of these champions who can collectively work to bring about large-scale policy changes.[17] By their nature, most leadership pools in professional organizations such as ASCE are shallow. A significant challenge for ASCE and other organizations is increasing member engagement and, crucially, identifying potential leaders and champions.[16]

Engagement

At the core of all aspects of this problem lies engagement. Engagement has been defined as “the process of building and managing the relationships between your organization and the people who help you achieve your mission.”[18] It is peculiar to every context and environment, but

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“...engagement is about an exchange of value. The members give time and money in exchange for value from their association. And more than ever, “time” is the real asset in that equation.” [19]

Following through on this line of thinking, ASCE as a mission-driven non-profit depends on its membership for “..everything from volunteering, advocating, voting and donating.”[20] ASCE’s membership has a widely varying set of skills, interests, and capacity to help and be motivated by different things. They have varying levels of engagement and commitment to the cause of infrastructure policy change and to ASCE itself. [20] Civil engineers can be motivated to associate themselves with ASCE membership if the society fulfills essential needs such as access to technical and career development information, networking with other professionals, and mentorship/leadership experiences. [16] Increasing member engagement for ASCE means developing “...strategies for improving members’ favorable attitudes to engage them.” [16] This requires a framework for identifying and tracking engagement across the ASCE membership and organization.[16] These frameworks can take various forms, such as the ladder of participation or the ladder of engagement. [15]

“These models depict lower-order forms of participation on its lower levels and progressively more intensive forms of engagement as one moves up towards more leadership-oriented roles.... (focusing on) ... roles and commitment levels rather than degrees of access to decision-making power.” [15]

ASCE’s Vision 2025 can only regain momentum if it identifies, recruits, and develops leadership at all levels, based upon a constituency (professional members who are activated) from a membership community (members who are concerned but not active) and then facilitating the engagement of membership at higher and higher levels of leadership until the pinnacle of championship is reached.

“Thus, the ladder of engagement reflects a process “whereby individuals take on more and more leadership” (Sinnott & Gibbs, 2014, p. 28). The lower rungs are occupied by supporters and leadership prospects who support the cause but have not assumed ongoing roles or commitments; organizers and emerging leaders occupy the ladder's higher rungs.” [15]

The pyramid concept takes this a step further. It conveys a relative proportionality between the levels of engagement that reflects the situation faced by ASCE; namely, most of its membership is at lower engagement levels. Therefore, the vertical dimension of the pyramid represents “the intensity of engagement, with low level, lightweight engagement at the bottom and high intensity, deep engagement at the top.” [20] At the bottom of the engagement pyramid, communications and relationships are technology-centric and more automated; at the top, they are more personal and labor-intensive.[21] A well-designed engagement pyramid becomes a powerful indicator of the overall organizational health and success of programs envisioned for civil engineering advocacy. Ideally, ASCE develops its members and moves them “up the pyramid,” where they assume “more and more valuable roles. The better you are at moving people up the

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pyramid, the more successful you should be as an organization.” [20] However, this pyramid model allows for multiple pathways from the lower level to the top. It should also be noted that members can enter or reenter the pyramid at any level depending upon their current engagement. With a well-constructed engagement pyramid, an organization such as ASCE can understand “...exactly what activities or qualities define supporters at each level”, and how many of those supporters (it) can count on in each level to take on different pieces of the organization’s work. [20]

“Unlike an engagement ladder — which usually defines an individual supporter’s single engagement path — the pyramid shows your organization-wide engagement and power.” [20]

Such engagement pyramids can take many different forms. However, one model developed by [Groundwire](#) (Rosenblatt) [22] offers characteristics that match that need for civil engineering advocacy and are used in this paper to illustrate how a pyramid may deepen the leadership pool and provide a pathway for developing champions.

- At the lowest level are **Observers** interested in ASCE’s mission but are not ASCE members. The Observer level is for potential membership and is the pool from which ASCE’s supporters emerge.
- The next level are **Followers** who are ASCE members but have not taken any advocacy actions or made donations.
- At the next level are **Endorsers** who are members that endorse ASCE’s mission by demonstrating their willingness to take small actions, including modest financial contributions to endorse ASCE’s effort to advocate for infrastructure policy change. They are somewhat interested in being more involved in ASCE’s mission.
- At the next level are **Contributors** who give a significant amount of time or money to ASCE, but they have yet to take on a leadership role. These contributors may have done the following: volunteered, contributed content, attended paid events and conferences, taken elevated action for advocacy, or made a more substantial financial contribution. Logically, this would correspond to ASCE’s “key contact,” “back home visits,” and “contact your legislator” programs.
- At the next level are **Owners** who are members who endorse ASCE’s mission by demonstrating their willingness to take on meaningful responsibility and authority to reach ASCE’s goals for infrastructure policy change. Owners are civil engineering spokespeople, super volunteers, and significant donors. Logically, this would correspond to ASCE’s “legislative fly-in” program. Notably, the previous programs cited as examples for “Contributors,” with time build engagement and move members to the next level, offer related but higher contact and advocacy activities and programs.
- The highest level is **Champions**, members who invested in ASCE’s mission by demonstrating their willingness to take on particular responsibility and authority to reach ASCE’s goals for infrastructure policy change. **Champions** are special donors of time, money, influence, and other resources who are heavily committed to ASCE’s mission. [20]

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Logically, this would correspond to the potential for the “advocate of the year award” program.[23]

Engagement tools such as the pyramid highlight gaps and areas where ASCE could lead its membership into deeper relationships that advance civil engineering advocacy and leadership; it also suggests ways in which ASCE can deepen its leadership pool. Pyramid models also allow ASCE to develop its “master leader” concept and link it to specific engagement levels, such as the champion and owner levels in the example above. Engagement models such as pyramids or ladders also allow ASCE to develop more granular strategies for improving members’ favorable attitudes and fulfill essential membership needs such as access to career information, networking with other professionals, and mentorship/leadership experiences.

The problem of creating educational and experiential pathways for future leaders

Professional societies expect that members will be leaders, not only of their profession but also of society-at-large. This expectation is particularly true for civil engineers in developing, funding, and constructing public infrastructure. [24] Becoming a “master leader” or champion as visualized by ASCE in its Vision 2025 requires both component-level and system-level expertise and the ability to explain the complexity of the infrastructures, associated policies, and critical decisions while engaging various people with diverse backgrounds in the discussions. [24] The crux of the issues surrounding this topic is the role played by the civil engineer as a manager and a leader.

Interchangeably referring to the terms “leadership” and “management” creates functional complications and long-term confusion over leaders' and managers' roles. [25] Blurring the difference between leadership and management is not just a matter of semantics but causes difficulties in measuring, testing, assessing, hiring, developing, and promoting them. [25] [26] Goethals et al. (2004), the Encyclopedia of Leadership editors, argue that “...there is no single and universally accepted definition of leadership.” [25] The literature on the two subjects often conveys that leaders are not managers and vice versa, but leadership and management are interrelated and perform similar functions. Leading is an essential skill for an effective manager [25], and in fact, Covey notes that “...leadership is the highest component of management.” [27] In the same vein, leading is not so much a specialized phenomenon or particular activity, but rather “... a highly salient aspect of managing.” [25]

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Toor (2008) argues that “although there are several existing and emerging branches of management, the definition of “management,” unlike that of leadership, is more or less agreed upon.” [25] leadership, on the other hand ...

“... is a process that involves vision, motivation, and actions of the leader that enables the followers to achieve certain collective goals. It involves the leader, followers, and the situation. The purpose of leadership is to provide direction and bring about change. ... leadership involves power by influence, and management involves power by position. Leadership is about coping with change, while management is about coping with complexity.” [25]

Managers and leaders both exert influence and, thereby, power.[28] The basis for the exercise of this power by management can be associated with job status or authority, having the ability to reward others, or the capacity to penalize or punish.[28] As Toor (2008) [25] and Northouse [28] note, power is a concept that is often associated with leadership. Social concepts of power identify the common and essential bases of power exercised by leaders as being [28]

- Referent power-reflects the leader's ability to generate feelings of identification and popularity with the followers.
- Expert power- reflects the leader's ability to demonstrate competence reflected in the followers' perceptions. Technical competence, in this example, is based upon possession of knowledge and the ability to apply that to solving problems.
- Legitimate power- reflects the leader's ability to achieve position status and formal authority (what is often termed positional power) over the followers.
- Reward and Coercive power- reflects the leader's ability to exercise influence by unbalancing either positively (reward) or negatively (coerce) influence individual follower's outcomes.[29]
- Information power- reflects the leader's ability to demonstrate possession of information that is useful or valued by followers. This form of power does not require possessing knowledge or demonstrating competence.

Sociology research groups these individual forms of power into archetypes of organizational power and personal power. [28] The former includes legitimate, reward/coercive, and information power in the leader. The latter includes referent and expert power in the leader. Power has been conceptualized as a relationship between the person influencing and the person(s) being influenced [28] and occurs only in relationships, ideally used to achieve collective goals. [28]

This discussion of power and influence is the core of what is necessary to move into the position of “master leader.” This section began with the observation that engineers are expected to be leaders, not only of their profession but also of society. There was and is little argument that there is an increasing demand for engineers to become better leaders. [25] However, the existing leadership research, including the preceding discussion on power use, often fails to convey engineering leadership's context and complexity. [27], [30]

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The primary context for engineering leadership can vary from interpersonal relationships in project teams to the relationship between the project office and the project stakeholders. Leadership development is an “inherently longitudinal ... process by which leaders acquire relevant experiences, skills, behaviors, and knowledge over time.”[31] Essential in this process is the role leader identity plays in leadership development. An individual with a “stronger, self-rated leader identity was associated with increasing leadership effectiveness” across time in an increasing manner. [31] Research indicates that this leader identity becomes more robust over time due to participation in leadership development, creating a positive identity spiral. This means that ...

“individuals ... exercise their leadership skills, receive a confirmation for their leadership claims, further align leadership behaviors with a leadership role, which will lead to stronger self-perceptions as a leader. Stronger leader identity then motivates an individual to further develop leadership skills through engagement with leadership.”[31]

Lastly, civil engineering leadership theories must also acknowledge the importance of context in the 21st century for civil engineers. Engineering leadership is more complicated than most social and business examples because of the prevalence of expert power in engineering teams and technical competence requirements.[27] Civil engineering projects and programs are the predominant vehicles for infrastructure delivery in the 21st century. [5] Civil engineers as individuals practice in an environment characterized by economic scarcity. [5] It implies more than limits on the availability of resources, or “scarce means,” but also limits to the profession’s knowledge and methods for reliably delivering projects (“limited methods”). The methods with limits could be civil engineering practices applied to solve design problems as part of technical competency and the solution of management problems as a part of management controls or management capacity.

While limits on resources or means are intuitive, limits on methods of management control or management capacity are not. [33] Management capacity has been defined as the project team's ability to complete the project within budget and schedule by engaging other stakeholders or resolving issues within defined constraints and assumptions.[34] The ability to deliver the project within the budget and schedule is limited by either natural or artificial constraints. Thus, civil engineering managers must have the ability to cope with and overcome these constraints by means of mobilizing additional authority and resources as necessary to deliver the project. [35] This paper argues that project success in civil infrastructure delivery is a function of management capacity and the capability to cope with constraints by changing the project team's ability to deliver it. The latter is a leadership function, a leadership capability that can augment management capacity supported by a solid foundation of technical competency. This concept agrees well with Covey’s observation above that leadership is the highest aspect of management; it can overcome the inherent limits of management control and project constraints.

Achieving large-scale infrastructure policy changes using this integrated management-leadership paradigm requires ASCE to solve two problems. First, develop a definition of civil engineering leadership that reflects the context and complexity of civil engineering practice in delivering

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21st-century infrastructure. (See also Ahn [37] on the necessity of an operational definition of engineering leadership.) Secondly, implement a leadership development program that recognizes the role of time in leadership and the longitudinal nature of leader development. A significant challenge for ASCE is to develop a comprehensive, integrated framework of leadership development that occurs at both the individual and collective levels, consisting of both skill acquisition and leadership maturation, and supported by performance and learning/development-based criteria. This fundamental insight in this leadership development over time supported by criteria-based assessment is that leadership maturation can be characterized as a step function.

Recommendations

The solution to the problems outlined above can be accomplished in several ways. The authors offer the following in the way of recommendation to ASCE for its consideration.

Vision 2050

ASCE should update the Vision 2025 document with a 2050 vision that recognizes ASCE's aspirations to be a significant factor in the American domestic economy's economic growth in the 21st century. ASCE seeks to instill confidence in the future and create an environment of predictability and reliability in project delivery that allows the private and public sectors to make investment decisions. A Vision 2050 document should revise social license to social capital, thus reframing the vision to be more practically focused on integrating engineers' role in society as a whole. Ideally, ASCE would provide the missing engineering solution to the infrastructure growth question in macroeconomic policy discussions. This would genuinely establish ASCE's bona fides as master leaders in policy discussions. Development of a 2050 vision should incorporate input from civil engineering practitioners and those in academia, and other experts in related fields, following a similar process of engagement through summit events and individual outreach as was used for the original Vision 2025 summit.

Engagement Tools

Building on the recent efforts taken by the organization, ASCE should develop more granular strategies for improving members' favorable attitudes and fulfill essential membership needs such as access to career information, networking with other professionals, and mentorship/leadership experiences. Engagement tools such as the pyramid highlight gaps and areas where ASCE could lead its membership into deeper relationships that advance civil engineering advocacy and leadership.

Comprehensive Definition of Leadership and updating the Engineering Grades

Advancement as master leaders requires a definition of leadership for civil engineering that recognizes the need to balance management capacity, technical competency, and leadership capability. This can be thought of as the three-legged stool of practice-skill in managing people, leading them, and developing technical solutions for delivering projects. ASCE is a recognized leader in advancing the state of practice and disseminating it to advance the profession and individual careers. Besides technical content, ASCE also has an extensive inventory of materials on leadership and leadership development. However, there are conceptual and practice gaps in

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these, particularly in leadership and influence for those maturing into later phases of practice and higher roles in infrastructure delivery. Foremost in them is the lack of references to leadership in the Engineering grades report [35], which requires a more precise definition to guide the development of master leaders. In recognition of this need, ASCE is undertaking efforts to organize development materials into curricula tied to the Engineering Grades.

Civil Engineering Body of Knowledge (4th edition)

As another example, the CEBOK consolidates leadership with teamwork and should expand the definition of these topic areas to assist with bringing in educational and experiential pathways for these areas. Formal descriptions into the next version of CEBOK will provide a framework that will then formalize the incorporation of necessary skills to realize the goal of developing “master leaders.”

ASCE Policy on Leadership

Implementing a leadership development framework that reflects the context and complexity of civil engineering practice in delivering 21st-century infrastructure and the longitudinal nature of leadership requires more policy direction to coordinate these critical guidance documents. However, there is no ASCE policy on leadership. Several policies touch tangentially on leadership. Policy 465, which supports the attainment of the CEBOK, implicitly addresses leadership but is not referenced. Even the engineering teams' policy fails to discuss the role of leadership and would be strengthened if this emphasis were to be added. Policy 535 on the civil engineering teams could be revised to reflect the context and complexity of civil engineering leadership in project teams.

Conclusions

One of this paper's key findings relates to the linkage between the ASCE Vision 2025 and Infrastructure Report Card projects. The Vision 2025 document visualizes civil engineers as trusted leaders in a modern world by serving as master leaders in shaping public infrastructure policy. [3] ASCE infrastructure policy reports support the Infrastructure Report Card project, such as the “failure to act” series. [36] While the report card recommends specific public infrastructure investment levels, the Vision or road map offers insufficient guidance on the path forward. This was addressed in the recommendations.

Similarly, neither the ASCE policy documentation nor the report card addresses the criticisms raised by the profession's stakeholders regarding how core infrastructure investment in the 21st century drives long-term GDP growth for the American economy. These criticisms of increased infrastructure spending are a direct challenge to the ASCE Infrastructure Report Card. They should be acknowledged and used to adjust future report cards to better position the profession in a master leader role. ASCE aspires to be a significant factor behind the American domestic economy's economic growth in the 21st century, instilling confidence in the future and creating the predictability and reliability that allows the private and public sectors to make investment decisions. Society acknowledges ASCE and the civil engineering profession because of its confidence in civil engineering and its ability to deliver civil infrastructure reliably and

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predictably. This should be part of rethinking or reimagining a new Vision 2050, as discussed in the recommendations above.

The role of master leaders in infrastructure policy discussions requires civil engineers to influence or create large-scale policy change, either directly or indirectly, which is civil engineering advocacy. Creating such a large-scale policy change for infrastructure requires “continuous and deepening levels” of engagement on the issues. ASCE’s experience with its Vision 2025 demonstrates that such initiatives can lose momentum, even perish if not sustained by an active membership and efforts to recruit champions using engagement tools such as the pyramid of engagement. These can only be solved by repositioning the profession to focus on building social capital, not social licenses, and lastly, achieving “critical mass,” i.e., mobilizing a sufficient number of these champions who can collectively work to bring about large-scale policy changes. The pyramid of engagement presented in this paper provides a framework for building critical mass and engagement in a strategic manner. ASCE’s successful legislative advocacy programs have been developed to bring members in at various engagement levels and serve as models for other efforts. Recommendations were made to address these challenges. Civil engineering leadership is complex and often discussed out of the context of 21st-century project delivery and civil infrastructure. Nevertheless, civil engineers demonstrate the ability to cope with and overcome these constraints through mobilizing additional authority and resources as necessary to deliver the project while applying sound technical analyses to develop innovative solutions, using both a detailed and systems thinking approach. Project success in civil infrastructure delivery is a function of management capacity and the capability to cope with constraints by changing the project team's ability to deliver it. The latter of which is a function of leadership, a leadership capability that can augment management capacity. Civil engineering leadership is the highest aspect of project management and can overcome the inherent limits of management control and project constraints.

Repositioning the profession and its practitioners as collective and individual leaders requires implementing targeted programs that recognize the role of time in leadership and leader development's longitudinal nature. A significant challenge for ASCE is to develop a comprehensive, integrated framework of leadership development that occurs at both the individual and collective levels in a step-wise fashion, consisting of both skill acquisition and leadership maturation, and supported by performance and learning/development-based criteria. Recommendations were made to address this above. This program can apply to formal education programs, mentorship efforts, and lifelong learning.

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