

# *Engineering Education Meets Organizational Science: Toward Best Practices for Strategic Change*

Jesse Pappas  
Department of Engineering  
Wake Forest University  
Winston-Salem, USA  
pappasj@wfu.edu

Olga Pierrakos  
Department of Engineering  
Wake Forest University  
Winston-Salem, USA  
pierrao@wfu.edu

**Abstract**—This Innovative Practice Full Paper explores how implementing best practices from organizational science can strengthen strategic change initiatives in engineering education. Transforming organizational culture has been a priority in engineering education for nearly four decades, but systemic change has not come easily, and long-standing goals remain elusive. Stagnant graduation and industry participation rates for women and underrepresented minorities have implications for establishing cultures of inclusion. Further, continued difficulty closing the research-to-practice gap in the engineering classroom points to faculty cultures that are resistant to, or unprepared for, change. Are such cultures immutable, or could our current interventional methods be improved? How much do we really know about planning and managing change, and could best practices from organizational science help catalyze the transformations we seek? To investigate this possibility, the state of change in engineering education is briefly reviewed and compared to two influential sets of universal best practices for managing organizational change. These practices are incorporated into six principles of good practice intended for use in engineering education contexts.

**Keywords**—Strategic change, change management, culture change, organizational science, interdisciplinary, innovative practice, best practices

## I. INTRODUCTION

Engineering education has a long modern history of strategic change initiatives and so far, transformation has not come easily. Among the most palpable examples are stagnant graduation and industry participation rates for women and underrepresented minorities reminding us year after year that cultures of equity and inclusion have yet to be realized at many universities [1] [2]. Blackburn [3] conducted a comprehensive literature review on the role of women in STEM higher education between 2007 and 2017. Systemic barriers and cultural threats are discussed throughout, but there is only one passage on strategic culture change – one direct reference in a review of 500+ publications. This indicates a lack of either attention or evidence in this domain, and both possibilities reflect a need to operationalize culture change in engineering education. From an academic perspective, abundant research on ways to better prepare students for professionalism has spurred notable strategic changes in some areas, but the research-to-practice gap remains wide [4] [5] [6] [7].

Not surprisingly, there is a long-standing sense of frustration among some in the field. Twenty years ago, Baba and Pawlowski [8] wrote:

While engineering education scholars and industry leaders agree that cultural transformation is called for, there is neither widespread understanding nor agreement about how to change culture. Some worry that this mission is truly impossible. Certainly, it is difficult to change any academic culture, since one of academia's characteristics is conservatism and a generally high level of resistance to change [8, p. 7E3-6].

In the introduction to his recent book on coping with accelerating change in engineering education, Kamp [9] characterized the current state-of-affairs in similar terms.

I have noticed a scary widening gap between the visionaries and thought leaders on the one side, and the majority of academic staff including higher management on the other side. There is so much skepticism to upgrade programs that have survived unaltered for decades. There is so much complacency with the status quo [9, p. 1].

The Summer 2019 issue of *Advances in Engineering Education* reflects a microcosm of the current state of change in our discipline. This special issue is the product of a community-wide ASEE effort to identify future directions for innovative research and practice [10]. The top four areas of inquiry identified by 187 subject matter experts were 1) Learning inside and outside the classroom, 2) Improving and diversifying the pipeline and pathways, 3) The role of technology, and 4) Change and culture in education. The first three topics were selected for development, and leaders in each domain were commissioned to write expositions. Why the topic of change and culture in education was not selected is a bit of a mystery, and perhaps it was simply the curse of coming in fourth but, based on the proliferation of cultural themes throughout the articles in the other three areas, it may be that culture change is perceived to permeate innovation across engineering education and therefore defies distinction. The invited manuscripts seem to bear out this notion. The term “culture” appears 13 times in the diversifying pathways paper [11], 15 times in the technology paper [12], and 93 (!) times in the improving student learning paper [6]. What's more, a significant portion of these cultural references convey both a recognition of importance and a lack of understanding of organizational culture. For example, Finelli and Froyd [6] put *changing the organizational culture* at the top of a list of needs for improving student learning while acknowledging that the

nature of such changes and plans to achieve them remain unclear.

In sum, strategic change is imperative, but best practices for transforming engineering education cultures have not yet been established, much less broadly adopted. This is not particularly surprising from a personnel perspective. Change management is rarely included in STEM curricula at any level, so faculty and students alike are working with limited frames of reference. Sluggish change, however, may be more attributable to engineering cultures themselves than to the individuals within them. Prior to the late 20<sup>th</sup> century, engineering education remained largely unchanged for many years. Such consistency (especially when combined with a history of success) can make strategic change exceedingly difficult. Edgar Schein, the “Father of Organizational Development” wrote: “One simply cannot change pieces of a stable culture without creating potential mass anxiety” [13, p. 33].

Within the organizational science literature, culture is sometimes compared to DNA – deeply embedded, influential, complex, and consistent, yet unique to each organization. Consequently, organizational scientists have devoted considerable resources to identify potent change management practices, some of which have been broadly formulated for effectiveness across all organizational cultures. Such universal practices may be comparably useful within engineering education contexts without modification. What’s more, the timing is quite good, because a definitive review and synthesis of best practices for managing strategic change was recently published [14].

*Is it time for engineering education to meet organizational science?* The present paper explores this potentiality. A brief review of universal practices for successful organizational change, as initially established by Kotter [15], and recently reformulated and extended by a team of leading researchers [14], is followed by a synopsis of existing strategic change theory within engineering education. Then, key recommendations from these sources are integrated into six Principles of Good Practice geared toward engineering education environments. Some direct quotes are included to provide interdisciplinary clarity.

## II. BEST PRACTICES FOR SUCCESSFUL ORGANIZATIONAL CHANGE

At the time of publication, searches of ERIC and IEEE Xplore databases for the terms “engineering education” and “organizational science” in any field returned just one result. Despite clear collaborative potential, rarely have these fields met to share knowledge. From an organizational science perspective, quite a lot is known about effectively transforming organizational culture. Numerous conceptual and practical models have been published, and for the practical purposes of the present project, we focused on operational models that provide specific recommendations for strategic intervention. Two best practice models stand out for their sound fundamentals, practicality, and broad influence. Kotter [15] integrated the results of hundreds of change management

initiatives across many industries to derive an eight-step process for leading change. This model is widely recognized as a seminal work in the field of organizational change [16] [17] and has been used to guide hundreds, if not thousands, of professional strategic change initiatives. Kotter’s model has also been implemented successfully in higher education environments, including STEM programs [18] [19]. Here are Kotter’s *Eight Steps for Leading Change*:

1. Establish a sense of urgency
2. Form a powerful guiding coalition
3. Create a vision for change
4. Communicate the vision
5. Empower broad-based action
6. Generate short-term wins
7. Consolidate and build on gains
8. Institutionalize the change

Kotter’s model remained the leading standard of practice for more than two decades. Then, in 2018, three leading organizational scientists published a comprehensive review and synthesis of the empirical literature on managing organizational change [14]. The article was published in a top organizational science journal and has been cited over 300 times in three years. This synthesis of existing knowledge yielded ten evidence-based practices for successful organizational change. They are universal, operational, and specifically designed to move interventional initiatives forward. Reassuringly, despite the addition of more than two decades of new evidence, the Ten Practices have much in common with Kotter’s Eight Steps. They are more specific, however, and include several new essential practices such as systematic diagnosis, attention to social networks, and formative assessment. Among the most significant innovations is increased flexibility. While Kotter insisted all eight steps be present and completed in sequential order, the Ten Practices come with no such requirement. The authors state that while some principles may apply earlier or later than others, most can be applied concurrently and repeatedly across the life of an initiative [14]. Here are Stouten, Rousseau, and De Cremer’s *Ten Practices for Successful Organizational Change*:

1. Get facts regarding the nature of the problem(s)
2. Assess and address the organization’s readiness for change
3. Implement evidence-based change interventions
4. Develop effective change leadership throughout the organization
5. Develop and communicate a compelling change vision
6. Work with social networks and tap their influence
7. Use enabling practices to support implementation
8. Promote micro-processes and experimentation
9. Assess change progress and outcomes over time
10. Institutionalize the change to sustain its effectiveness

Have we been taking such steps in our efforts to transform engineering education? Could adapting and applying these best practices help catalyze progress in areas that have so far been resistant to change? The present investigation begins to address such questions and seeks to establish paths for further

interdisciplinary cooperation. But first, some essential context via an overview of existing perspectives on managing organizational change in engineering education.

### III. ENGINEERING EDUCATORS ON MANAGING ORGANIZATIONAL CHANGE

A small body of work investigating organizational change within engineering programs has emerged since the turn of the century. While studying the impact of globalization on engineering education, Lucena [20] made an early clarion call for expert knowledge in this domain.

The demand for flexible engineers presents significant challenges to engineering education. Among these is the need for engineers to be prepared to understand and deal with organizational change. Yet engineering education and research on engineers have overlooked the impact of organizational change on engineering work [20, p. 321].

Godfrey [21] - [24] proposed, and then built upon, a conceptual model of engineering education culture. Her work focuses on mapping fundamental elements of culture to enable change. Key concepts include:

1. Engineering educators should become knowledgeable about theories and models of organizational culture and culture change before pursuing strategic change [21].
2. The first step to successfully changing a culture is a clear understanding of the existing culture [21] [23].
3. Change at curricular, structural, and behavioral levels is not sufficient for cultural transformation. Sustainable change requires new collective understandings, beliefs, and values [23].

The *ADVANCE* Institutional Transformation Initiative was established in 2001 to enhance equity and inclusion in academic and professional workplaces [25]. Bilimoria and Liang [26] synthesized outcomes from *ADVANCE* initiatives at nineteen universities into a framework for organizational change intended to serve as a template for universities seeking cultural transformation (see Figure 1 below). Like Godfrey's assessment of engineering education culture before it, the framework is well-crafted, evidence-based, and *conceptual*, so it stops short of making practical recommendations to drive strategic intervention.

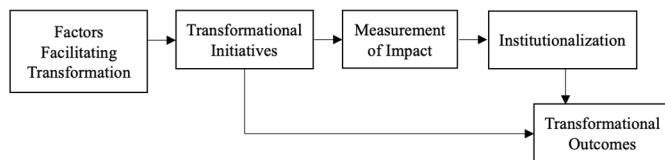


Fig. 1. Institutional Transformation Framework adapted from Billimoria and Liang [26]

Also noteworthy from a conceptual perspective is Finelli and colleagues' [5] [6] work on managing organizational change to improve student learning and bridge the research-to-practice gap. Their more recent article, which was noted in the introduction, proposes four themes for future research on improving student learning identified through a large, faculty-

driven Delphi study. The first theme, "change the organizational culture," is broken down into the following four categories:

1. Understand organizational culture
2. Ascertain where change is needed
3. Clarify the relationships between organizational culture and teaching and assessment practices
4. Identify strategies and tactics to change organizational culture

A rare published interventional initiative by Quinn and colleagues [27] leveraged several well-known change management approaches for a blended learning collaboration between two Australian engineering schools. The team used Kotter's [15] eight-step framework to successfully merge academic cultures and noted that the first three steps – creating a sense of urgency, forming a coalition, and developing a vision – were especially critical because they provided the meaning and motivation to drive change processes forward.

In sum, a strong core of conceptual knowledge and well-founded, but relatively general, recommendations for strategic change have been established in engineering education. Some elements of best practice have been published, but two primary areas of need remain, including (1) unification and clarity among existing recommendations in the engineering education literature, and (2) identification of additional practices to enable strategic intervention. The remainder of the present paper begins to address these needs by synthesizing knowledge from engineering education and organizational science into principles of good practice.

### IV. IDENTIFICATION OF PRINCIPLES OF GOOD PRACTICE FOR MANAGING CHANGE IN ENGINEERING EDUCATION

Stouten, Rousseau, and De Cremer's Ten Practices [14] and Kotter's Eight Steps [15] were designed for use by professional organizations, which typically have significant history, infrastructure, and resources dedicated to strategic change. In engineering education (and academic programs in general), strategic change initiatives are typically less extensive and explicit, if they are explicit at all [28]. There is no evidence to suggest, however, that universal change strategies developed for corporate cultures should not be similarly effective in academic environments. With this in mind, we resisted an impulse to modify existing best practices to match perceived characteristics or specific needs of engineering education. Instead, we sought to preserve the core directives while also allowing insights from relevant engineering education literature to guide our formulation process. Using this strategy, our research team synthesized the Eight Steps, the Ten Practices, and existing work from engineering educators into six principles of good practice for managing strategic change in engineering education. Testing these principles in engineering education contexts is, of course, essential to assessing their current value and the potential need for more significant tailoring (for more on this, see the Limitations and Future Work section on page 6).

## PRINCIPLES OF GOOD PRACTICE FOR MANAGING STRATEGIC CHANGE IN ENGINEERING EDUCATION

### Principle One: FUNCTIONAL DIAGNOSIS

Source material:

*Ten Practices (Stouten, Rousseau, and De Cremer)*

- Get facts regarding the nature of the problem(s)
- Assess and address the organization's readiness for change

*Engineering Education Literature*

- Understand existing organizational culture [6] [21] [23]
- Ascertain where change is needed [6]
- Identify factors that facilitate implementation [26]
- Identify and remove barriers to change [11]

*Rationale for Functional Diagnosis* – A key contribution of the Ten Practices model [14] is the importance of thoroughly diagnosing the problem at hand and the organization's readiness for change before taking strategic action. Kotter's Eight Steps [15], the previous standard bearer for more than two decades, excluded diagnosis entirely. Most theoretical models of organizational change published by engineering educators do include diagnosis as a first step, but interestingly, none of the models reviewed include early diagnosis (or later engagement) of impeding factors – barriers to change. This theme is found in literature on the topic of strategic change, however. For instance, Simmons and Lord's [11] work on diversifying pathways in engineering, which is noted in the Introduction, emphasizes the importance of removing (often invisible) barriers to culture change that are often systemically embedded. Such problems can be hard to identify and harder to address because the system must be shifted away from its status quo. Overcoming systemic barriers requires a thorough diagnosis of existing cultural standards and practices leading to community efforts to adopt new collective mindsets.

A clear understanding of how targeted problems are manifest within organizational culture is critical to subsequent interventional success, but the culture should also be diagnosed independently. According to Stouten, Rousseau, and De Cremer [14], this involves studying the organization, change, outputs, and outcomes from multiple perspectives. Assessing the organization's readiness for change is also important. Readiness refers to the ability of the organization and its people to meet the demands associated with strategic change. Sometimes functional diagnosis may reveal alternate paths or ready solutions that negate the need to engage the interventional processes defined in Principles Two through Six. As philosophers have said in many ways, sometimes the solution lies within (understanding) the problem itself.

### Principle Two: COMPELLING VISION

Source material:

*Ten Practices (Stouten, Rousseau, and De Cremer)*

- Develop and communicate a compelling change vision

*Eight Steps (Kotter)*

- Establish a sense of urgency
- Communicate the vision

*Engineering Education Literature*

- Demonstrate importance of developing a vision and creating a sense of urgency [27]
- Form new collective understanding, beliefs, and values [23]

*Rationale for Compelling Vision* – Engineering education literature is rife with visions of change but how, exactly, such visions are formulated and communicated within academic programs to foment change is rarely addressed. In his more recent work, Kotter [29] writes that vision can translate opportunity into action. An effective vision creates a sense of urgency and appeals to a diversity of stakeholders. Research has shown that broadly appealing visions often focus on attractive goals and potential positive outcomes rather than dire warnings and lamentations on the current situation [30] [31]. Godfrey [23] argues that cultural transformation requires shared beliefs and common values. From a psychological perspective, like a team goal, a vision is likely to be effective if most stakeholders accept it and become committed to achieving it [32]. Clearly, but how do you get everyone on the same page? Organizational science has not fully answered this question, and the specific features that characterize a compelling vision of change remain somewhat unclear. Recommendations include making the vision broadly appealing while also being specific about individual roles and responsibilities. Understanding stakeholder perspectives is also important. Gathering targeted information from various groups, such as students, faculty, and staff, can help identify motivating factors. In terms of the *process* of communicating a vision, organizational research highlights the importance of consistent communication through multiple channels such as meetings, media, and one-on-one interactions. The value of repeating one's vision over time and conveying a logical, evidence-based message are also supported by organizational research [14].

### Principle Three: INTERVENTIONAL DESIGN

Source material:

*Ten Practices (Stouten, Rousseau, and De Cremer)*

- Implement Evidence-Based Change Interventions

*Engineering Education Literature*

- Identify strategies and tactics to change organizational culture [6]

*Rationale for Interventional Design* – Strategic change requires strategic action, and such action should be guided by evidence-based practice. Our informal review of nearly forty years of engineering education literature on culture change revealed that (1) published initiatives are more likely to be theoretical or conceptual than interventional, and (2) a lack of consensus around good interventional practice. Reports of changes implemented at the course, departmental, or university level often describe rationales, results, and implications in far greater detail than the associated interventional processes. Stouten, Rousseau, and De Cremer's [14] Ten Steps are built entirely upon experience gained from interventional practice. Engineering education can learn from organizational science in

this regard – change requires action, and strategic change theory that is not directly linked to interventional data may be regarded with a degree of suspicion. Finelli and Froyd [6] recently took a deep dive into strategies for improving student learning via cultural intervention and, as noted in the Introduction, they reported that the nature of effective change in engineering education remains clouded. With few sources of discipline-specific methodological evidence to build upon, cultural transformation is likely to remain quite difficult. We may benefit our programs and educational community by developing, documenting, and publishing interventional practices in the manner of social and organizational science.

Organizational research highlights the importance of interventions that develop change-related skills, offer rewards and incentives to motivate change, and provide opportunities to practice change activities in supportive environments [33] [34]. Note that these best practices target the individual rather than the group. In their influential book on transformational change management, Anderson and Ackerman-Anderson [35] highlight the need for distributed interventional practice as discussed in the next section, as well as the potential importance of attending to individual goals like self-mastery.

Culture change requires interventions at all levels of organization—whole system, team, relationships, and individuals. All must be aligned with the new directions and serve the content changes being made. Leaders can use organization-wide interventions such as visioning, values clarification, breakthrough and Self-Mastery training, governance, corporate policy, communications processes, and human resources practices [35, p. 100].

#### Principle Four: DISTRIBUTED IMPLEMENTATION

Source material:

*Ten Practices (Stouten, Rousseau, and De Cremer)*

- Develop effective change leadership throughout the organization
- Work with social networks and tap their influence
- Use enabling practices to support implementation

*Eight Steps (Kotter)*

- Form a powerful guiding coalition
- Empower broad-based action

*Engineering Education Literature*

- Demonstrate importance of forming a coalition [27]

*Rationale for Distributed Implementation* – This principle encompasses multi-level practices that share a common purpose of helping change spread through an organization. Interventions should be driven by a distributed implementation strategy that features multiple sources of leadership working together as an empowered network, which Kotter [15] [36] calls a powerful guiding coalition. Effective communication and messaging across the targeted academic unit facilitate broad awareness and receptivity. A distributed implementation plan will consider the potential influence of various social networks such as distinct groups of students, faculty, or staff. These distributed practices are contrasted by centralized strategies in which the implementation of an interventional

initiative is driven by a single source or node of influence [14]. Centrally managed interventions can gain broad adoption, especially in the presence of a charismatic leader [37]. However, distributed practices that empower multiple nodes of leadership and influence are more likely to catalyze systemic transformation [38] - [40]. Another way to describe this approach is both top down *and* bottom up. For instance, a change initiative can be promoted by administrative leadership while individual faculty members simultaneously implement it at the classroom level.

Distributed social networks also play an important and often overlooked role in influencing organizational change. Change agent effectiveness is derived from a combination of individual ability and network connections. Interventional practices should be tailored for maximum impact at multiple organizational levels. For instance, individuals in cohesive teams are more likely to respond positively to appeals that engage the whole team as opposed to communication that is disconnected from their team [41] [42]. So, if you are seeking buy in from a department with tight-knit faculty, consider pitching your change plan at a team meeting rather than visiting individual offices (and vice versa).

#### Principle Five: AGILE MANAGEMENT

Source material:

*Ten Principles (Stouten, Rousseau, and De Cremer)*

- Promote micro-processes and experimentation
- Assess change progress and outcomes over time

*Eight Steps (Kotter)*

- Generate short-term wins
- Consolidate and build on gains

*Engineering Education Literature*

- Measure impact [26]

*Rationale for Agile Management and Assessment* – Agile approaches to project management emphasize segmentation, iteration, flexibility, formative assessment, and periodic goal revision. This approach effectively unites several best practices for managing strategic change in the organizational and engineering education literature. Kotter's Eight Steps suggest leveraging the benefits of multiple short-term wins to build momentum, while the Ten Practices take a more objective, experimentation-based approach:

These processes entail the use of multiple small interventions to support learning by doing and to create test beds for identifying effective interventions, experimenting to see which change elements bring the best results. Small-scale interventions also allow adjustment to local elements in the organization or industry [14, p. 777].

Bilimoria and Liang's [26] Institutional Transformation Framework (see Figure 1 above) includes assessment as an essential step in the strategic change process, although the model is comprised of sequential steps that necessitate the completion of an initiative prior to summative assessment. Alternatively, the organizational science models we reviewed recommend formative assessment during the interventional process to determine if an ongoing initiative is producing

anticipated outcomes. The *Harvard Business Review* recently published a set of agile practices for change managers based on a “test-and-learn” approach using short sprints (time-boxed work stages). Minimally viable results are regularly tested and may inform process improvements prior to further implementation [43]. Agile methodologies are becoming increasingly popular in engineering education [44] - [46] so for some teams, using agile strategies to manage strategic change projects may be relatively straightforward.

#### Principle Six: INSTITUTIONAL ADOPTION

Source material:

*Ten Principles (Stouten, Rousseau, and De Cremer)*

- Institutionalize the change to sustain its effectiveness

*Eight Steps (Kotter)*

- Institutionalize the change

*Engineering Education Literature*

- Institutionalization [26]

*Rationale for Institutional Adoption* – Sustainable culture change requires the integration of new values, expectations, and practices into broader organizational systems. True transformation involves the emergence of new values, leading to new ways of thinking and acting. When the time comes to scale your successful change initiative to the institutional level, you have reached the reinforcement stage. At this point, changes should be strengthened, consolidated, and merged into the organization’s existing processes and structures [47]. Institutionalization does not mean abandoning successful processes that got you this far. On the contrary, faced with the full power of the institution, you will need to work harder than ever to preserve the original vision, empower distributed leadership, attend to individual outcomes, and sustain continuous improvement. Clarify to the community at large how strategic change has led to specific improvements and leverage incoming data to make positive outcomes visible across the organization [48] [49]. You will know change has been institutionalized when it is no longer perceived as change and become part of your organizational culture.

#### V. LIMITATIONS AND FUTURE WORK

Engineering education and organizational science have rarely been studied in concert. The present work is intended to the expose potential benefits of this interdisciplinary collaboration within the domain of strategic change. But this is just a start. Describing the principle of Interventional Design, we stated that non-interventional studies should be regarded with a degree of suspicion, and admittedly, the present work belongs in this category. We have taken care to base our recommendations on the results of interventional practice, but until these principles of good practice are tested in engineering education contexts, they are just ideas. Further, while the principles are informed by engineering education research, they are predominantly based on the results of professional interventions by organizational scientists and practitioners. Best practices for transforming organizational culture within academic and engineering environments may diverge in

important ways. Interventional research that evaluates the utility of the Six Principles across various engineering education contexts is needed to determine their practical value. Research is also needed to identify additional principles of good practice for managing strategic change.

Our research team is currently conducting a methodological analysis of published strategic change initiatives in engineering education. The goal is to gain practical insight into common challenges, strategies, and outcomes among both theoretical and interventional efforts. The results of this analysis will be strategically compared to the principles proposed here to inform further development. We are also investigating how other persistent challenges in engineering education may be informed by organizational science, and we hope others are inspired to do so. Caches of relevant knowledge that exist beyond our disciplinary borders will only be found if we look for them.

#### VI. CONCLUSION

Interdisciplinary collaborations are currently setting new standards in engineering education (for a review, see [50]). Students and faculty alike are now regularly combining theories, concepts, and methods across disciplines to solve complex problems. Still, the collaborative potential of engineering education and organizational science remains largely untested. The Six Principles of good practice for strategic change proposed here represent the first steps of this interdisciplinary exploration. Through further investigation, implementation, and refinement of such practices, engineering educators and administrators may be able to transform even the most conventional organizational cultures.

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