Changing Engineering Education: Views of U.S. Faculty, Chairs, and Deans

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Abstract

Background Many reports present a vision of *what* engineering education should look like, but few describe *how* this should happen. An American Society for Engineering Education initiative in 2006 attempted to bridge this gap by engaging faculty, chairs, and deans in discussion of change in engineering education; results were reported in a Phase I report (2009). In a second phase, survey data were integrated into a Phase II report (2012).

Purpose This article uses the ASEE survey results to identify promising pathways for transforming engineering undergraduate education.

Design/Method The survey asked faculty, chairs, and deans at engineering departments at 156 U.S. institutions to reflect on the recommendations of the Phase I report. Quantitative and qualitative responses were separately analyzed and then mixed by mapping findings to the Four Categories of Change Strategies model developed by Henderson et al. (2011), which frames the results and illustrates gaps and opportunities.

Results Responses mapped to three of the four categories of the model that were most commonly used in other STEM education efforts: developing and disseminating new instructional approaches, supporting faculty members in their own scholarly teaching, and implementing policies that enable and reward teaching innovation. No responses mapped to developing a shared vision through activities such as strategic planning.

Conclusions The greatest promise for transformative change in engineering education lies in developing a shared vision for educational innovation. The findings of this article provide a foundation for ongoing discussion and evaluating progress.

Keywords faculty attitudes; instructional change; survey methods

Introduction

In recent years many national reports from the United States have urged engineering education stakeholders to change both the curriculum and pedagogy that traditionally have been standard parts of engineering education (Duderstadt, 2008; National Academy of Engineering [NAE], 2004, 2005; National Research Council [NRC], 2007; National Science Board [NSB], 2007; Nielsen, 2011). Similar reports have also come from Europe and Australia (Borri & Maffioli, 2007; King, 2008), and similar conversations are also underway in other

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fields (American Association for the Advancement of Science, 2011). The concerns reflected in these reports include a lack of preparation for solving complex problems in rapidly changing global workplaces (NAE, 2004, 2005), a lack of diversity (Borrego & Bernhard, 2011; Chubin, May, & Babco, 2005; Duderstadt, 2008), a lack of attention to how people learn (NSB, 2007), and the need for more multicultural and cross-disciplinary educational experiences (NAE, 2005). In general, recommendations addressing those concerns include adoption of active learning and student-centered pedagogies, inclusion of authentic problems in coursework (King, 2008; Nielsen, 2011), incorporation of global competencies and international education, development of teamwork and communication skills, and enrichment of ethics and sustainability (King, 2008). Educating engineers in the humanities, entrepreneurship, and interdisciplinary subjects has also been repeatedly advocated (Borri & Maffioli, 2007; King, 2008; NAE, 2004).

Despite publication of numerous reports, the systematic changes they recommend have not been widely implemented (Borrego, Froyd, & Hall, 2010; NSF, 2008) because, in part, the reports focus on *what* engineering education should look like and usually provide little or no guidance on *how* to achieve this vision (ASEE, 2009). The lack of widespread change can also be attributed to the presence of powerful structural and systemic features of engineering education, such as its reward structures that favor the status quo (Borrego et al., 2010; NSB, 2007). To address the gap between (1) recommendations in the reports and knowledge about effective teaching and learning and (2) change processes to achieve this vision, in 2006 the American Society for Engineering Education (ASEE) undertook a unique initiative, Advancing the Scholarship of Engineering Education: A Year of Dialogue, to engage faculty, department chairs, and engineering deans in discussions of change in engineering education. On the basis of the idea that for change to occur we need to better understand what the community wants, needs, and values in engineering education, the initiative sought to engage the engineering community in the change process (Olds, Borrego, Besterfield-Sacre, & Cox, 2012).

The overall timeline for the initiative is given in Table 1. First, a committee of over 100 engineering education faculty members and administrators developed a report of what it wanted, needed, and valued in engineering education titled *Creating a Culture of Scholarly and Systematic Innovation in Engineering Education* (ASEE, 2009). The goal of this Phase I report was to "catalyze a conversation within the U.S. engineering community on creating and sustaining a vibrant engineering academic culture for systematic educational innovation" (p. 1).

The Phase I report delineated the *how*, *who*, and *what* of creating a culture for scholarly and systematic innovation. *How* needs to involve "a vibrant community of practitioners and researchers working in collaboration to advance the frontiers of knowledge and practice" (ASEE, 2009, p. 1). To that end, the report proposed "a model for scholarly and systematic engineering educational innovation based on a continual cycle of educational practice and research." Regarding *who* needs to be involved, the report recognized many stakeholders but maintained that primary responsibility lies with engineering faculty and administrators. The report's specific recommendations for various groups of stakeholders are identified in Table 2. *What* they should be working towards is alignment and unification between curriculum, instruction, and assessment, with all three "derived from a scientifically credible and shared knowledge base" (p. 1). The report also emphasized the need to create engaging, relevant, and welcoming learning environments. For instance, active learning and what the report calls "engaging pedagogies" (including inquiry learning, problem- and project-based learning, case-based learning, guided discovery, and just-in-time teaching) are important means for responding to what is known about how students learn.

Table 1 ASEE Initiative Timeline

Date	Project event
2004–05	Project design and planning by the ASEE leadership and a committee of members.
2006–07	ASEE launches the year of dialogue beginning with a Socratic session at its 2006 annual conference. Structured discussions within the Society on the role and importance of educational innovation are held during the following year.
2007–08	Results of the year of dialogue are published (Mohsen et al., 2008). They lead to a two-phase project funded by the National Science Foundation involving a project team of 68 engineering education stakeholders.
2008–09	Phase I report, *Creating a Culture for Scholarly and Systematic Innovation in Engineering Education*, is published in June 2009 (ASEE, 2009; Melsa, Rajala, & Mohsen, 2009) and presented at the 2009 annual conference. Phase II is launched seeking feedback via a survey on the Phase I report from a large national sample of engineering faculty, department chairs, and deans. In parallel, the Phase I report is presented at many national and international meetings and feedback is gathered.
2009–11	Results of the survey are analyzed and a draft final report prepared. The draft report is peer-reviewed by an independent committee of thought-leaders in engineering and education. The final report, *Innovation with Impact*, is published in November (ASEE, 2012).
2009–13	Preparation and reporting of additional survey results.

This report was followed by a survey to find out how the greater engineering education community viewed the engineering education system. The survey employed a mixed methods survey approach across multiple levels in the engineering community to better understand the gaps and begin to overcome them. These survey results informed the Phase II report, *Innovation with Impact* (ASEE, 2012).

Our research project uses the Phase II survey data to identify additional promising pathways for transforming engineering undergraduate education in the United States; it provides a baseline for ongoing discussion of change in engineering education. It addresses the following research questions:

> What are the significant differences in faculty responses by institution type and procedure used to develop a consensus response on behalf of the department?
>
> Which practices recommended in the Phase I report are practiced by U.S. engineering programs? Which are valued?
>
> What are the similarities and differences in how faculty, department chairs, and deans responded to similar questions about the challenges of creating a local culture of scholarly and systematic innovation?
>
> What promising new emphases can be identified from engineering faculty and administrator beliefs/responses about engineering education's current practice and future directions?

The present survey project directly analyzes the responses of engineering faculty, their department chairs, and deans to questions about change in engineering education. To frame the results and to combine quantitative and qualitative findings, we used the Four Categories of Change Strategies model developed by Henderson, Beach, and Finkelstein (2011).

Table 2 Summary of Suggested Actions from Phase I Report

Stakeholder	Suggested actions
Engineering faculty, chairs, and deans	Link engineering education practice and research Support and recognize educational innovation Prepare future faculty Integrate the curriculum Promote learning through entrepreneurship Educate the global engineer Develop leaders Promote learning through service Enhance faculty experience
American Society for Engineering Education	Develop national resources Disseminate and promote innovations
National Academy of Engineering	Create an engineering education section Create prestigious symposium on engineering education Broaden list of Grand Challenges
Professional engineering societies	Promote educational innovation Expand collaborations
ABET accreditation agency	Enhance the accreditation process Focus more on learning
Industry	Increase access to industry experiences (e.g., internships, sabbaticals) for faculty members and students Increase connections to education
Funding agencies	Substantially increase funding for proposed innovations Establish competitive long-term faculty-practitioner "trading places" programs Support assessment research Support faculty preparation and development for educational scholarship

Source. ASEE (2009).

Specifically, we mapped quantitative and qualitative survey responses to the four categories to identify emphases and gaps.

Literature Review

Contexts of Change

On the basis of a literature review, Henderson et al. (2011) identified four categories of change strategies that have been used to change science, technology, engineering, and mathematics (STEM) education and arranged them in a foursquare. The axes indicate what facet of the system was primarily affected (individuals or environments and structures) and to what extent the outcome was known in advance (prescribed or emergent). Prescribed refers to specific outcomes such as use of a pedagogy, curricular materials, or assessment tools; emergent outcomes are not necessarily known at the time the change strategy is initiated. The four categories, as well as their advantages and disadvantages, are summarized in Table 3.

Thirty percent of the 191 articles reviewed fell in the Individuals/Prescribed category (disseminating best practices, modifying instructor conceptions, and providing individualized

Table 3 Four Categories of Change Strategies Model Summary

Category	Description	Aspect changed	Intended outcome	Advantages	Disadvantages
Curriculum and Pedagogy	Inform individuals about new teaching concepts and practices and encourage their use	Individuals	Prescribed	Developing good curricula is beyond the skills and available time of most faculty Change agents can experimentally document effectiveness of new curricula and compare alternatives	Faculty may use new curricula inappropriately or not at all Most effective curricula conflict with traditional environments
Reflective Teachers	Encourage and support individuals to develop new teaching concepts and practices	Individuals	Emergent	Faculty have ownership of the new curricula New curricula are customized to the instructor and teaching environment	Faculty-developed materials may not be as informed as those developed by educational researchers Traditional environments do not reward a focus on teaching
Policy	Develop new environmental features that require or encourage new teaching concepts and practices	Environments and structures	Prescribed	Traditional environments are often barriers to change Can often be implemented relatively quickly	Faculty may subvert policy changes Loose coupling of university environments tends to complicate top-down efforts
Shared Vision	Empower and support stakeholders to collectively develop environmental features that support new teaching concepts and practices	Environments and structures	Emergent	Group norms are key change lever and not easily changed by policy changes Incorporates specialized knowledge of stakeholders throughout the system	New shared vision may not be in the direction desired by change agent No clear guidance available for change agents Resource intensive

Note. Adapted from Henderson et al. (2011).

diagnosis and support), 31% in Individuals/Emergent (supporting individual curriculum development, collaborative action research, helping faculty make informed decisions, and departmentally based faculty development specialists), 14% in Environments and Structures/Prescribed (system synchronicity, institutionalization of quality assurance measures, and directed incentives), and 5% in Environments and Structures/Emergent (institutional-level actions, externally initiated department collaboration, and internally initiated department collaboration). Henderson et al. (2011) concluded that STEM change agents have thus far focused primarily on the individual level of change.

In addition to the lack of attention to systems and environments, Henderson and his colleagues observed other common weaknesses across the categories. Only 40% of the strategies included moderate evidence of change or lack of change, and none included strong evidence of change. They also found a lack of references to "change literatures," with fewer than half of the articles drawing from such literatures. Additionally, they identified distinct groups of change agents (STEM faculty, faculty developers, higher education researchers, and administrators), and they observed that each group tended to work independently of the others and to have its own strategies and perspectives on STEM change. Discipline-based STEM education researchers and faculty development researchers focus on individual change, while higher education researchers focus on environmental and structural change (Henderson, Finkelstein, & Beach, 2010). Henderson, Beach, Finkelstein, and Larson (2008) argued that these groups need to be more interdisciplinary and work together rather than in isolation to influence the knowledge and experience of the others. They concluded that a literature synthesis bringing together the findings from the different disciplines would be useful.

Among disciplinary-based STEM education researchers, the category Curriculum and Pedagogy has been the dominant approach to change. It has been successful in increasing awareness of and interest in innovations but not in increasing implementation or adoption of them; it persists because it seems to make sense intuitively (Henderson et al., 2010). A more effective change model should focus on emergent outcomes and structural changes; such a model requires enrolling faculty as partners in the reform process (Henderson & Dancy, 2008; Henderson et al., 2010). To do that we need to understand the local environment – the situational and institutional constraints – and how it affects the faculty's ability and inclination to innovate (Henderson & Dancy, 2009). Because change is a factor of the combination of individual characteristics, such as beliefs, values, and knowledge, and situational characteristics (Henderson & Dancy, 2009; Murray & Macdonald, 1997; Norton, Richardson, Hartley, Newstead, & Mayes, 2005; Prosser & Trigwell, 1999; Sunal et al., 2001), it is those situational constraints, including availability of resources, institutional reward system, and disciplinary expectation, that need more attention in change models.

Many scholars similarly contend that to understand change, environments, structures, and their complex influence on individual decisions must be taken into account (Kezar & Eckel, 2002; Lattuca & Stark, 2009; Rogers, 2003; Seymour, 2001; Wejnert, 2002). For example, Lattuca and Stark (2009) provided a detailed picture of the complexities of the systems in which curriculum and innovation exist and the factors that influence faculty decisions. Their systems model highlights the wide range of factors – external (markets, governments, accrediting bodies), institutional (college mission, resources, governance, institution type and culture), departmental (faculty, discipline, student characteristics, culture), and individual (personal experiences and educational background, career stage, and professional development opportunities) – that influence educational plans, processes, and outcomes.

Hence, faculty decisions regarding change are influenced by the structures and context of the systems in which they work.

Barriers to Change

Because change occurs in the complex systems and environments described above, barriers to change need to be understood in terms of environmental and systemic constraints. The following barriers have been identified by prior studies: expectations of content coverage, limited instructor time for multiple responsibilities, lack of training and curriculum materials, departmental norms, student resistance, class size and room layout, time structure, fiscal resources, appropriate facilities, and institutional reward structures and culture, particularly research priorities (Borrego et al., 2010; Dancy & Henderson, 2010; Froyd, Layne, & Watson, 2006; Henderson & Dancy, 2007; Kezar & Eckel, 2002; Massey & Zemsky, 1994; Merton, Clark, Richardson, & Froyd, 2001; Milem, Berger, & Dey, 2000; Rugarcia, Felder, Woods, & Stice, 2000; Seymour, DeWelde, & Fry, 2011; Sunal et al., 2001). More specifically, by tending to favor research over teaching, systems and reward structures promote the status quo in teaching and curriculum (Borrego et al., 2010; Henderson & Dancy, 2011; Milem et al., 2000; Soyster, 2008). These barriers mean that sometimes features of an innovation are adopted only superficially with the result that instructors may wrongly conclude that an innovation is ineffective (Henderson, 2005; Henderson & Dancy, 2005; Seymour et al., 2011). The problem of status quo or insufficient adoption is compounded by the fact that faculty often do not have good ways to measure the effectiveness of teaching (Dancy, Turpen, & Henderson, 2010; Turpen, Dancy, & Henderson, 2010). Further, even though change agents know about environmental and structural barriers, they often fail to address them and do not provide tools to overcome them in their dissemination efforts to faculty and administration (Finkelstein & Pollock, 2005). Therefore, individual-level actions are promoted, while environmental and structural barriers are ignored, a discrepancy that stands in the way of change. Finally, external influences, which are noted as one factor in change, may not be seen as legitimate within a department and therefore may not motivate faculty to change (Lattuca, Terenzini, & Volkwein, 2006).

Prior studies have shown that while many faculty are aware of and are interested in STEM education innovations, that awareness and interest does not translate into widespread action (Borrego et al., 2010; Dancy & Henderson, 2010; Dancy et al., 2010; Henderson & Dancy, 2007, 2008, 2009; Turpen et al., 2010). Therefore, the biggest impediment to change is not a lack of knowledge about effective teaching methods, but a lack of knowledge on how to increase or diffuse the use of those methods (Froyd, 2011; Henderson & Dancy, 2011). The ASEE initiative grew out of the recognition that this gap between research and practice – supported by structures that favor the status quo – needs to be overcome if we are to create cultures that support the scholarly and systematic innovations discussed in the Introduction.

Recommendations for Change

To overcome barriers to STEM education innovations, members in the STEM education community have offered many recommendations. For example, deans and departments should:

> Find ways to diffuse innovations to faculty members in other departments who teach engineering students. (Lattuca, 2011; Merton et al., 2001)

> Provide opportunities for graduate students to learn about innovative teaching methods (supervised and mentored teaching and reflection opportunities) and hire graduates

with a record of interest in teaching and curriculum development. (Lattuca, 2011; Lattuca & Stark, 2009)

Provide professional development opportunities for faculty to learn about teaching, curriculum design, and student learning by means of teaching and learning centers and workshops (Lattuca & Stark, 2009) and continuous discussion, evaluation, and assessment of curricula, teaching, and learning. (Lattuca & Stark, 2009; Merton et al., 2001)

Reward faculty who have made improvements in teaching and learning and remove disincentives for trying; establish official criteria that value and reward teaching, both monetarily and in tenure and promotion. (Lattuca & Stark, 2009; Merton et al., 2001)

Create new structures, positions, and policies to accommodate innovations. (Lattuca & Stark, 2009)

Give faculty extra time such as release time or extensions on the tenure and promotion period to try new methods. (Seymour et al., 2011)

Engage senior colleagues with power and influence in the change process. (Merton et al., 2001; Seymour et al., 2011)

Offer faculty easily accessible and useful resources for implementing teaching innovations. (Lattuca & Stark, 2009; Seymour et al., 2011)

Professional societies and disciplinary communities should offer professional development opportunities for faculty, chairs, and deans to emphasize the importance of effective teaching (Lattuca, 2011). Researchers should provide evidence that innovations work (Dancy & Henderson, 2010; Merton et al., 2001; Seymour, 2001; Seymour et al., 2011), explicitly study change strategies, research secondary implementations, develop teaching effectiveness tools, and encourage policies to measure teaching effectiveness that are based on student learning goals (Henderson & Dancy, 2011). Moreover, all stakeholders should work to build communities, networks, and personal relationships in order to develop knowledge and promote the adoption of innovations (Borrego et al., 2010; Seymour et al., 2011; Sunal et al., 2001).

In all these efforts, faculty need to be partners in the change process, not merely receivers of knowledge after it is produced (Henderson & Dancy, 2008; Henderson et al., 2010). Recommendations for enrolling faculty as partners in change include providing easily modifiable materials, focusing on the dissemination of research ideas in addition to curriculum improvements, and emphasizing personal connections more than reproduced presentations that lack reflective conversation (Henderson & Dancy, 2008; Henderson et al., 2010). Strategies for overcoming student resistance to change as well as variations in content coverage as a function of the innovation have been summarized elsewhere (Froyd et al., 2008).

As noted, the ASEE initiative responded to the lack of impact such prior recommendations have had in the engineering education community. The Phase I report both reiterates and extends these prior recommendations and makes specific recommendations for a broad array of engineering education stakeholders (ASEE, 2009). Table 2 summarizes these recommendations. In addition to these recommendations, the Phase I report advocates a cyclic model for change that aligns with the Four Categories of Change Strategies model (Henderson et al., 2011) and focuses on systems and emergent outcomes that enroll faculty in the change process. The report's model is "based on a continual cycle of educational practice and research" (ASEE, 2009, p. 6) that involves collaboration between practitioners and researchers. The Phase I report provides numerous real and hypothetical examples of how the cyclic model can be and has been engaged. The Phase I model also emphasizes the need for alignment and unification between curriculum, instruction, and assessment, with all three "derived from a scientifically credible and shared knowledge base" (ASEE, 2009, p. 1). Therefore, engaging the model and aligning these facets of education requires attention to the development of policies, a shared vision, and reflective teachers that – in Henderson et al.'s (2011) terms – support educational innovations.

Methods

Survey Instrument

The Phase II survey was developed in January and February 2010 on the basis of the key recommendations of the ASEE Phase I report. The survey was developed by Barbara Olds, Maura Borrego, Mary Besterfield-Sacre, and Monica Cox. Leah Jamieson and Jack Lohmann, authors of the two ASEE reports, served as co-directors and contributed to the survey development.

The survey instrument was designed to obtain feedback from faculty, chairs, and deans regarding their organized thoughts after reading the Phase I report. The resulting survey consisted of six parts. The first four parts were directed at faculty in departments, the fifth part was directed at the department chair, and the sixth at the engineering dean. The complete instrument can be found in Appendix A of the *Innovation with Impact* report (ASEE, 2012). Because the instrument was developed directly from the Phase I report, it did not undergo a pre-review by experts, peers, or stakeholders because they were intimately involved in producing the report. An informal pilot with several faculty members was conducted to verify that the questions and items were interpreted as intended by the researchers.

At each institution, faculty members were asked to read the Phase I report and then form a committee to provide their shared thoughts about the report. Hence, faculty responses were collective in nature. Following these open-ended questions, the faculty members were asked to rate a series of items in terms of their importance in advancing a culture of innovation in engineering education (1 = Not important, 2 = Somewhat important, 3 = Important, and 4 = Highly important), as well as degree of practice in the responding department (1 = We currently do not practice this, 2 = We practice this somewhat, 3 = We practice this routinely, and 4 = We consider ourselves leaders in this). The specific items and their results are given in Table 4. Faculty members were then asked to respond to two open-ended items, listed in Table 5. The department chair was then asked to read the report and the department faculty's response and respond to the open-ended item listed in Table 5. Upon completion, the chair forwarded the combined responses (chair and faculty) to the dean. The dean, in turn, reviewed the responses and responded to a similar open-ended item (Table 5).

Survey Administration and Data Collection

Two samples of institutions were selected for the survey. The first set comprised 100 institutions with at least one engineering program enrolling at least five students. The sample consisted of 65 public and 35 private institutions. Once the institutions were selected, two engineering programs from each institution were selected to participate in the survey, stratified to be representative of engineering disciplines, except in cases where there was only one engineering department.

Table 4 Closed-Form Survey Results

	Importance			Practice		
	n	*M (SD)*	*p*	*n*	*M (SD)*	*p*
1. Collaborate with the following stakeholders in educational innovations:						
a. Mathematics and natural sciences	109	3.32 (0.73)	**0.000**	110	2.41 (0.82)	0.877
b. Humanities and social sciences	110	2.36 (0.70)	0.978	110	1.89 (0.87)	1.000
c. Business, architecture, law, etc.	110	2.54 (0.66)	0.282	110	1.98 (0.66)	1.000
d. Education, learning science, psychology, etc.	110	2.72 (0.85)	0.004	110	1.81 (0.76)	1.000
e. Engineering technology	109	2.72 (1.00)	0.013	109	2.28 (1.02)	0.985
f. Industry and employers	110	3.46 (0.69)	**0.000**	110	2.83 (0.76)	**0.000**
g. Pre-colleges and community colleges	110	2.32 (0.87)	0.985	110	1.80 (0.75)	1.000
2. Exercise the following pedagogies in undergraduate instruction:						
a. Inquiry-based learning	110	3.05 (0.76)	**0.000**	110	2.32 (0.73)	0.995
b. Experiential learning (e.g., PBL)	110	3.31 (0.65)	**0.000**	110	2.71 (0.77)	0.003
c. Collaborative learning	110	3.25 (0.70)	**0.000**	110	2.68 (0.74)	0.006
3. Exercise the following pedagogies in graduate instruction:						
a. Inquiry-based learning	91	3.38 (0.77)	**0.000**	88	2.63 (0.73)	0.056
b. Experiential learning (e.g., PBL)	90	3.23 (0.82)	**0.000**	87	2.53 (0.80)	0.370
c. Collaborative learning	91	3.10 (0.80)	**0.000**	88	2.52 (0.73)	0.385
4. Engage undergraduate students in the following learning environments:						
a. Laboratories	110	3.74 (0.50)	**0.000**	109	3.24 (0.51)	**0.000**
b. Cooperative education and internships	109	3.09 (0.70)	**0.000**	109	2.68 (0.73)	0.006
c. International programs	109	2.56 (0.79)	0.215	109	2.38 (0.88)	0.928
d. Research	109	3.01 (0.70)	**0.000**	109	2.73 (0.75)	**0.001**
e. Entrepreneurship programs	109	2.46 (0.69)	0.734	109	1.97 (0.85)	1.000
f. Engineering competitions	108	2.69 (0.63)	**0.001**	108	2.54 (0.74)	0.302
g. Service learning programs	108	2.26 (0.74)	0.999	108	1.90 (0.86)	1.000
5. Engage graduate students in the following learning environments:						
a. Laboratories	89	3.33 (0.84)	**0.000**	87	2.71 (0.83)	0.010
b. Cooperative education and internships	89	2.38 (0.78)	0.922	87	2.06 (0.70)	1.000
c. International programs	89	2.17 (0.86)	1.000	87	1.87 (0.80)	1.000
d. Research	88	3.90 (0.34)	**0.000**	86	3.37 (0.65)	**0.000**
e. Entrepreneurship programs	87	2.37 (0.84)	0.928	85	1.82 (0.86)	1.000
f. Engineering competitions	88	2.07 (0.83)	1.000	86	1.79 (0.69)	1.000
g. Service learning programs	82	1.90 (0.73)	1.000	82	1.51 (0.71)	1.000
6. Support additional learning environments through:						
a. Mentoring programs	105	2.88 (0.74)	**0.000**	105	2.35 (0.73)	0.979
b. Engineering extracurricular activities	106	2.87 (0.65)	**0.000**	106	2.57 (0.73)	0.177

Table 4 (continued)

	Importance			Practice		
	n	*M (SD)*	*p*	*n*	*M (SD)*	*p*
7. Create next-generation engineering educators by:						
a. Integrating instruction/practice of pedagogy into graduate programs	88	2.95 (0.79)	**0.000**	85	1.98 (0.77)	1.000
b. Providing graduate students with opportunities in engineering education research	88	2.33 (0.89)	0.962	85	1.64 (0.75)	1.000
c. Encouraging industry experience for faculty and future faculty	103	2.71 (0.80)	0.005	103	1.98 (0.83)	1.000
8. Engage career-long development programs in teaching and learning	104	2.94 (0.69)	**0.000**	104	1.93 (0.80)	1.000
9. Carry out the innovation cycle of educational research and practice	106	2.64 (0.75)	0.027	105	1.80 (0.76)	1.000
10. Create the physical infrastructure necessary to facilitate the innovation cycle	104	2.86 (0.85)	**0.000**	104	1.83 (0.86)	1.000
11. Obtain fiscal resources to sustain practicing the innovation cycle	106	3.08 (0.78)	**0.000**	104	1.82 (0.80)	1.000
12. Have policies and practices to support the innovation cycle	103	2.93 (0.78)	**0.000**	102	1.73 (0.75)	1.000

Note. Significant p-values marked in bold given Type I error of $\alpha_{item} \leq 0.001$.

A second purposeful sample consisted of 73 engineering schools that were selected on the basis of their appearance on one or more top 20 lists, such as the *U.S. News & World Report* rankings. Seventeen institutions were included in both samples. The purposeful sample increased the number of schools that potentially engaged in innovations associated with engineering education. The engineering deans of these institutions were asked to select two departments to respond to the survey.

The final combined invited sample was 156 engineering schools, consisting of 26 baccalaureate colleges, 40 master's colleges and universities, and 90 doctorate-granting universities. Forty-six percent of the engineering schools responded, which included 110 individual engineering programs. Nine baccalaureate colleges, 17 master's colleges and universities, and 46 doctorate-granting universities responded to the survey.

Data Analysis

In addition to the results published in the Phase II report, additional quantitative and qualitative analyses were conducted on the data, and these results are provided in this article.

Quantitative data analysis We conducted quantitative data analysis on the closed-form portion of the survey data. One limitation of our study is that the set of responding institutions may not be representative of the broader population of engineering undergraduate programs. To understand whether there were differences in faculty responses by institution characteristics or the process used to compose a common department response, we conducted t-tests or one-way analysis of variance (ANOVA) tests. Table 6 lists five subgroups that were tested. We investigated potential differences between top 20 schools versus those

Table 5 Open-Ended Survey Items

Respondents	Survey items
Faculty members (one response per department)	1. As a committee, please identify the most compelling parts of the report. Specifically, comment on the top three priorities that can advance a culture of scholarly and systematic innovation in engineering education in your department.
	2. As a committee, please identify the principal opportunities your faculty have and/or challenges they face to achieve the top three priorities described in Question 1.
Department chair	In your role as chair of the department, what are the principal opportunities you have and/or challenges you face helping your department create a culture of scholarly and systematic innovation in engineering education?
Dean (or equivalent)	In your role as dean of the college, what are the principal opportunities you have and/or challenges you face helping all your departments create a culture of scholarly and systematic innovation in engineering education?

schools not appearing on a top 20 list (e.g., *U.S. News & World Report* rankings). Institutional type was analyzed by the one-way ANOVA to determine differences between bachelor's, master's, and doctorate institutions; a *t*-test was conducted to determine if there were differences in departments' opinions between public and private institutions.

Another potential limitation of our study was lack of control over the procedures each department followed to compose a single department response. "Level of input from faculty" and "committee presence of chair or dean" each address this limitation. For these two variables, it was important to determine if there were any biases in the survey responses based on the faculty committee composition or size. For the variable "level of input from faculty," we consulted Part 1 of the survey whereby departments were asked to provide information on faculty completing the survey: "Tell us who prepared the response to this survey, i.e., the number of committee members, distribution by rank, whether it is a standing or ad hoc committee, and whether the final response includes input from department faculty beyond the committee." From the responses, a sorting system was used based on the size of the department. If only one member of the department completed the questionnaire with no stated input from other faculty, a 0 was assigned; if a small group of approximately three formed the committee and there was no stated input from the other department faculty, a 1 was assigned; if the committee consisted of four or five members and there was some stated input from other faculty, a 2 was assigned; and if there was a substantial number of persons, (e.g., six or more), as well as input from faculty, a 3 was assigned. For the variable "influence of chair or dean," we again consulted Part 1 of the survey. If a chair or dean was listed as a member of the committee, a 1 was assigned; otherwise, a 0 was assigned.

To answer our first research question, we tested the extent to which items were valued by engineering departments and the extent to which items were routinely practiced. Specifically, a one-tail *t*-test was performed, using PASW Statistics version 18, to determine if engineering departments valued the various collaborations, in-class pedagogies, learning environments, professional development, as well as policies and practices of engineering schools. Likewise, a similar test was performed on the same items to determine the degree of practice

Table 6 Subgroups Tested for the Closed-Form Items of the Survey

Subgroup	Variables	Test applied
Top twenty vs. not top twenty	0 – top 20; 1 – not top 20	*t*-test
Level of input from faculty	0 – none; 1 – very little; 2 – sufficient; 3 – much	ANOVA
Institutional control	0 – public; 1 – private	*t*-test
Institution type	1 – bachelor's; 2 – master's; 3 – Ph.D.	ANOVA
Committee presence of chair or dean	0 – no influence; 1 – influence by chair or dean	*t*-test

departments followed for the particular item. We defined departments that indicated a 3 or 4 on the importance scale as valuing that particular item, and departments that indicated a 3 or 4 on the degree of practice scale as practicing the item on a routine basis. Hence, for each item two separate one-tailed *t*-tests were performed with the hypothesis $H_o \leq 2$ and $H_a > 2$. Further, because there were 34 items in the closed-form questionnaire, a conservative Bonferroni adjustment for multiple comparisons was applied to the experiment Type I error of $\alpha \leq 0.05$ resulting in an individual item Type I error of $\alpha_{item} \leq 0.001$ (Larpkiattaworn, Muogboh, Besterfield-Sacre, Shuman, & Wolfe, 2003). The significant results were then mapped to the Four Categories of Change Strategies model (see Figure 1).

Qualitative data analysis For the qualitative data analysis, we applied both content analysis (Krippendorff, 2004) and open coding (Strauss & Corbin, 1998) to the open-ended survey items listed in Table 5. We made an initial examination of all the qualitative data and parsed this data into overarching themes by group (i.e., faculty, chairs, and deans) using content analysis. The basis for this content analysis was items represented in the quantitative survey; that is, the initial codes were based on, for example, the pedagogies or learning environments in the quantitative survey items. This preliminary review of the open-ended question responses was mapped to the quantitative closed-form survey items; however, the responses were too varied for this to be a meaningful coding scheme.

The open-ended responses coded into two themes: professional development (48 open-ended responses from 16 faculty, 18 chairs, and 14 deans) and rewards (54 open-ended responses from 15 faculty, 18 chairs, and 21 deans). Faculty professional development opportunities included activities that enhance engineering faculty (and sometimes graduate student) acquisition of skills or experiences related to educational innovations. Rewards included any incentives given to engineering faculty to promote or recognize their implementation of educational innovations. To map these to the four categories of the model, one member of our team conducted two rounds of analysis (one for each theme). Both times, the member read all responses for each theme, operationalized the responses in terms of the model descriptions provided in Table 3, and identified examples provided for each category by stakeholder groups. The translation of the categories for both themes is presented in Table 7. The results of these mappings are presented for professional development in Figure 2 and for rewards in Figure 3.

Mixing quantitative and qualitative data By design, the survey involved concurrent, triangulation mixed methods (Creswell & Plano Clark, 2007). The survey was concurrent because it allowed for simultaneous collection of both quantitative and qualitative data. It was a triangulation design because the quantitative and qualitative data were given equal weight in the analysis. Although the survey collected data from faculty, chairs, and deans, it was not necessarily parallel data. Faculty contributed quantitative and qualitative responses,

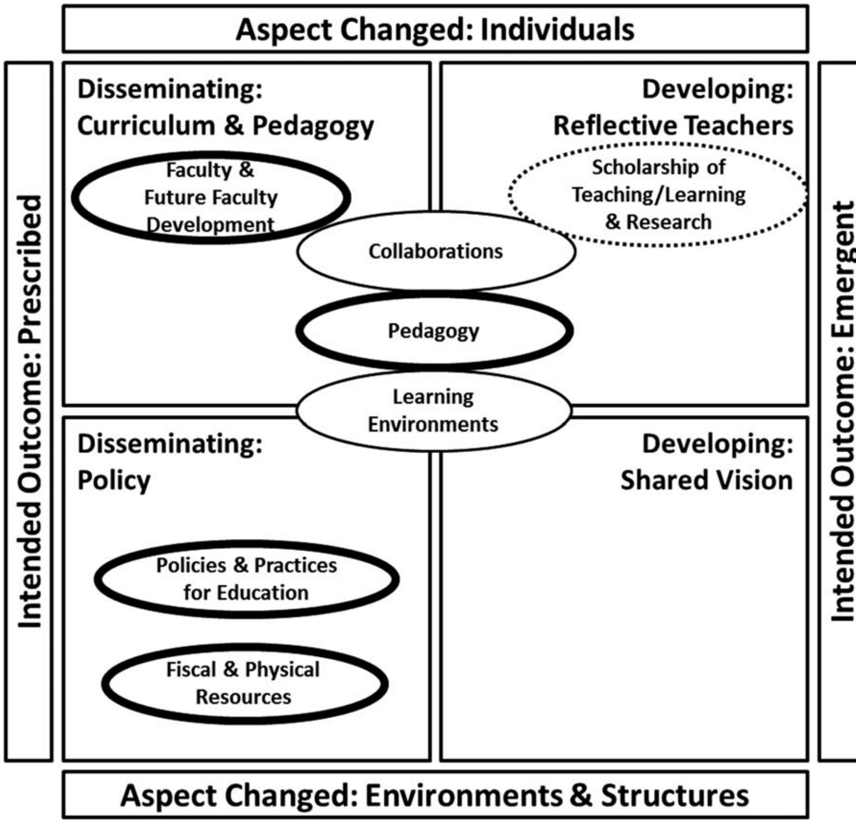

Figure 1 Quantitative data mapped to the Four Categories of Change Strategies model (Henderson et al., 2011). Bold lines around groupings indicate high value among faculty.

while chairs and deans contributed only qualitative data. Chairs and deans had the benefit of seeing responses from those they oversaw. To combine the results and better understand the challenges and opportunities that schools conveyed, we mapped major findings to the Four Categories of Change Strategies model. Within the qualitative findings, direct comparisons were made between the responses of faculty, chairs, and deans. Comparisons could also be made across the quantitative and qualitative results. In the Results section, Figures 2 and 3 place the survey results into the four categories identified by Henderson et al. (2011). The four categories provided an opportunity to describe what elements of the engineering education system are and are not being addressed as reported by faculty, chairs, and deans.

Results and Findings

Quantitative Results

Differences by institution and response process As mentioned, for both importance and practice two separate one-tailed t-tests were performed for each item with the hypothesis:

Table 7 Translation of the Four Categories of Change Strategy Model across Qualitative Themes

Change-strategy category	Themes	
	Professional development	Rewards
Curriculum and Pedagogy	Focus on *how* faculty and students will learn about professional development	Ways that incentives may be used to inform faculty about educational innovations
Reflective Teachers	Ways that faculty are engaging in professional development to help them learn about educational innovations	Ways that incentives are used to encourage faculty to become educational innovators
Policy	Newly developed features that encourage professional development related to educational innovations	New ways that incentives are used to reward faculty for their educational innovations
Shared Vision	Collective features that allow all stakeholders to create professional development opportunities related to educational innovations	Ways that stakeholders work together to create incentives that reward faculty for educational innovations

Note. Adapted from Henderson et al. (2011).

$H_o \leq 2$ and $H_a > 2$. The subgroups described above (Table 6) were tested to statistically determine whether engineering departments actually valued or readily practiced the particular item. For the first three variables listed in Table 6, no significant differences were found at $\alpha_{item} \leq 0.001$ related to the importance or degree of input; therefore, they will not be discussed further. For other items, statistically significant differences were found for "institution type" and "committee presence of chair or dean." Specifically, for institution, two items were found to be significant. The first item related to undergraduates and research; departments from bachelor's institutions did not rate the value of engaging undergraduate students in research as highly as did those departments from doctoral institutions. In terms of degree of practice, bachelor's institutions rated the degree of practice of engaging undergraduates in research significantly lower than did both master's and doctorate-granting institutions. Engineering may differ from other disciplines in the degree to which it readily engages undergraduates in research. Other disciplines in baccalaureate institutions promote undergraduate research and often require undergraduates to write a senior thesis; whereas in engineering, a culminating capstone project is the preferred requirement. There were also significant differences in value and practice for engaging graduate students in research, which is to be expected because not all responding institutions offer graduate degrees.

Regarding "committee presence of chair or dean," one item was found to be significant, related to the importance for cooperative education or internships. Faculty who completed the survey without the presence of the chair or dean rated cooperative programs and internships significantly higher than did faculty who had a chair or dean on the committee completing the survey. It is not clear to us why this difference was significant.

In general, the differences were reasonable and explainable. Because the subgroups in Table 6 did not appear to be different from one another, we considered data from all the departments as the focus of this article.

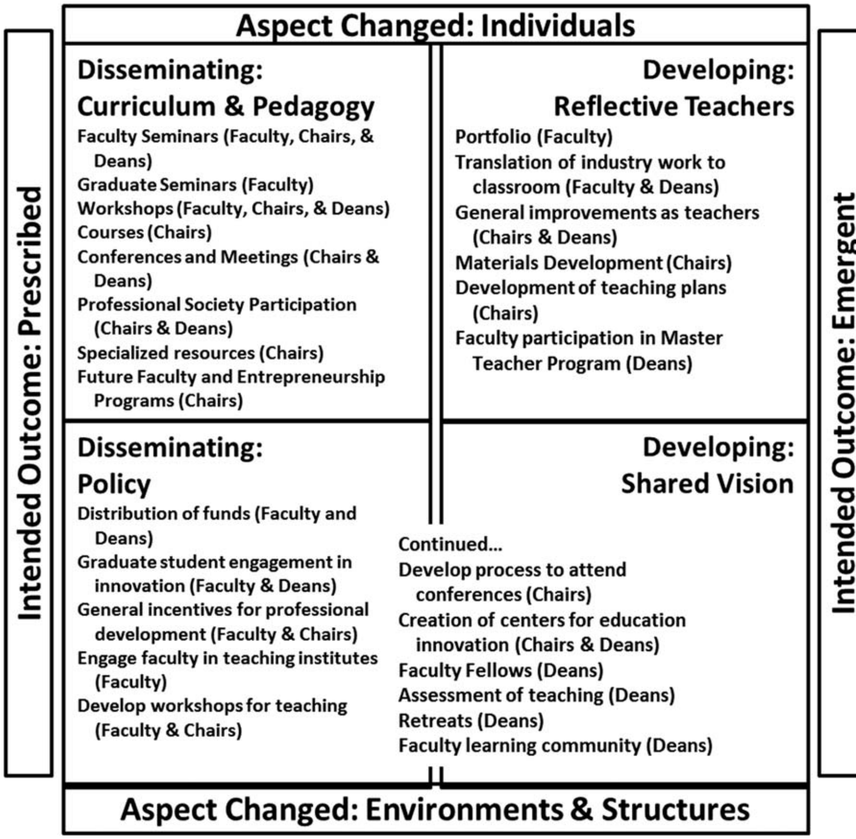

Figure 2 Faculty development opportunities mapped to the Four Categories of Change Strategies model (Henderson et al., 2011).

Value and practice of report recommendations Table 4 provides the results of the closed-form portion of the survey. Overall, Table 4 indicates faculty valued many of the items; however, there are fewer significant items that indicate the faculty readily practiced them. For example, faculty significantly valued collaborations with stakeholders (item 1) in mathematics and the natural sciences as well as with industry and employers. However, they only reported practicing such collaborations with industry and employers. Other types of collaborations were not found to be significantly important, including those with the humanities and social sciences, business and law, or precollege and engineering technology. Although not significant, engineering faculty did value collaborations with the education and learning sciences fields ($M = 2.72$, $SD = 0.85$, $p = 0.004$).

In terms of pedagogies, at both the undergraduate and graduate levels (items 2 and 3), faculty significantly valued active learning approaches such as inquiry-based learning, experiential learning, and collaborative learning techniques; however, departments did not report practicing these active learning approaches.

The results regarding learning environments (items 4 to 6) are mixed. At the undergraduate level, laboratories and research are both statistically valued and routinely practiced by

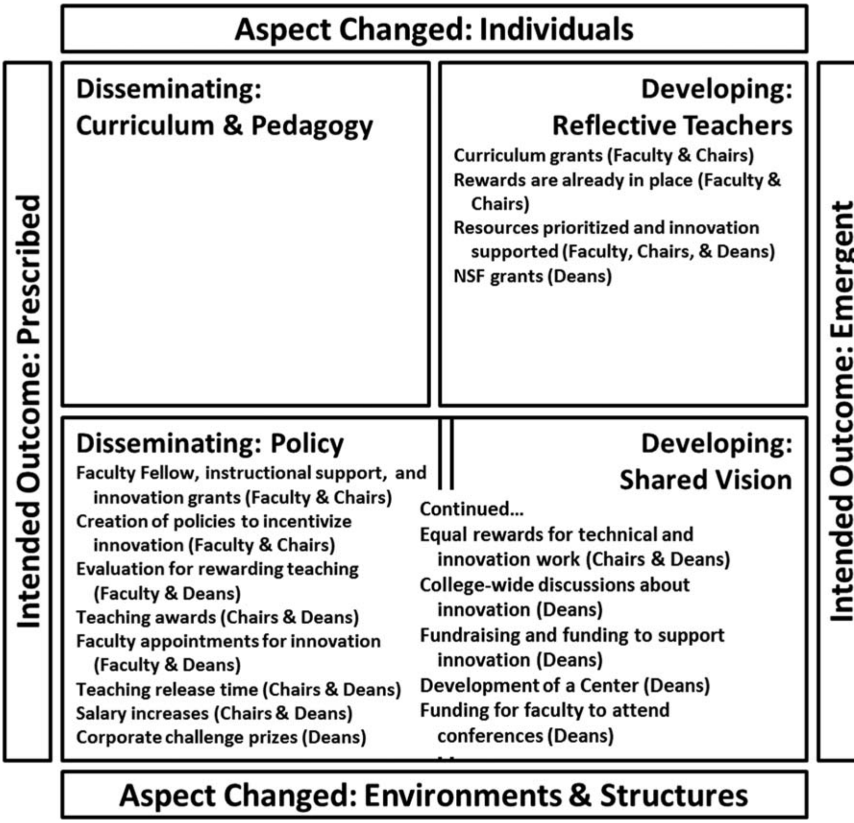

Figure 3 Rewards opportunities mapped to categories of the Four Categories of Change Strategies model (Henderson et al., 2011).

engineering faculty. Less surprising, research is significantly valued and practiced at the graduate level as well. Engineering faculty also valued cooperative education and engineering competitions at the undergraduate level as well as mentoring programs and other extracurricular activities; however, these learning environments are not significantly practiced in engineering. Interestingly, international programs, entrepreneurship programs, and service learning programs are clearly not valued by engineering faculty despite being prominently featured in many national and international reports such as those cited in the Introduction. The relative undervaluing of international programs and service learning may be linked to influences in engineering programs, as Lichtenstein, McCormick, Sheppard, and Puma suggest (2010).

In terms of preparing next-generation faculty and continued faculty training in pedagogy (items 7 to 9), there is significant support among faculty for training the next-generation engineering instructors as well as teaching and learning development programs for faculty; unfortunately, such programs are not routine practice. Further, although engineering faculty believe it is important to have graduate and postdoctoral students prepared to teach in the classroom, having students engage in engineering education research is not found to be important by engineering faculty, nor is having engineering faculty carry out the innovation cycle of educational research and practice (ASEE, 2009, p. 6), as they would typically do for their own traditional engineering research.

Finally, engineering faculty statistically value policies and practices that facilitate implementing well-researched teaching pedagogies and improvement practices (items 10 to 12) as well as resources that improve teaching and learning infrastructure and practices that sustain the innovation cycle. Survey results clearly indicate that such practices, although valued by faculty, are not practiced by them.

Mapping to the four categories model These departmental results were then mapped to the Four Categories of Change Strategies model. Because the change-strategy model was developed primarily for undergraduate STEM education, we did not include the two survey elements related to graduate education (items 3 and 5). Further, to simplify the results, the survey was abridged to seven areas, as shown in Table 8.

Figure 1 shows how the closed-form responses map to the change-strategy model. We did the mapping on the basis of discussion and consensus. Specifically, we placed the Faculty and Future Faculty Development grouping in the Curriculum and Pedagogy category because open-ended responses described these in terms of workshop-like opportunities for faculty to learn about specific instructional approaches. Policies and Practices and Fiscal and Physical Resources groupings were placed in the Policy category because school-wide or institution-wide commitments are usually needed for these types of changes, and the open-ended responses described funding in terms of specific initiatives. The Scholarship of Teaching/Learning and Research grouping was placed in the Reflective Teachers category. The items in this grouping involve faculty and graduate students conducting their own scholarship as related to teaching.

Two groupings (Collaborations and Pedagogy) overlapped with the Curriculum and Pedagogy and Reflective Teachers categories. While focused more on individuals than organizations, these two groupings represent both emergent and prescriptive outcomes. For example, instructors may adopt a new type of pedagogy based on a workshop they attend, or they may use their own knowledge and experience to improve their instructional practices with the help of an instructional designer who encourages and supports reflective practices by the instructor. The open-ended responses supported some flexibility in implementing instructional approaches. Examples of Collaborations include academics from different fields collaborating on a project to improve certain aspects of a course, or a cooperative program meeting with potential industry representatives to learn how a company can engage with the engineering school. Finally, we believed that the Learning Environments grouping touched on all four categories of the model because this broad grouping may support outcomes that are prescribed or emergent and may begin with an individual or require environments and structures be put in place.

In Figure 1, the groupings signify the quantitative results (Table 4). If the grouping was not significant in terms of both routine practice and importance, it was denoted with a dotted line around the grouping, as with Scholarship of Teaching/Learning and Research. If the grouping was found to be significantly valued (found to be important by faculty), it was denoted with a bold line (e.g., Policies and Practices for Education). Finally, if the grouping produced mixed results (i.e., some aspects were valued and practiced and other aspects were not), it was presented with a thin line (e.g., Collaborations). This visual representation makes it clear that the engineering faculty who responded to this survey clearly favored prescribed outcomes.

Qualitative Findings

Professional development Opportunities for professional development as identified by the coding for faculty, chairs, and deans are presented in Figure 2. Of special note is the way

Table 8 Survey Elements Represented in the Four Categories of Change Strategy Model

Survey grouping	Survey element and corresponding items (Table 7)
Collaborations and Stakeholders	1. Collaborate with the following stakeholders in educational innovations: a. Mathematics and natural sciences b. Humanities and social sciences c. Business, architecture, law, etc. d. Education, learning science, psychology, etc. e. Engineering technology f. Industry and employers g. Pre-colleges and community colleges
Pedagogy	2. Exercise the following pedagogies in undergraduate instruction: a. Inquiry-based learning b. Experiential learning (e.g., PBL) c. Collaborative learning
Learning Environments	4. Engage undergraduate students in the following learning environments: a. Laboratories b. Cooperative education and internships c. International programs d. Research e. Entrepreneurship programs f. Engineering competitions g. Service learning programs
	6. Support additional learning environments through: a. Mentoring programs b. Engineering extracurricular activities
Faculty and Future Faculty Development	7. Create next generation engineering educators by: a. Integrating instruction/ practice of pedagogy into graduate programs c. Encouraging industry experience for faculty and future faculty
	8. Engage career-long development programs in teaching and learning
Scholarship of Teaching/Learning and Research	9. Carry out the innovation cycle of educational research and practice
	7. Create next generation engineering educators by: b. Providing graduate students with opportunities in engineering education research
Fiscal and Physical Resources	10. Create the physical infrastructure necessary to facilitate the innovation cycle
	11. Obtain fiscal resources to sustain practicing the innovation cycle
Policies and Practices	12. Have policies and practices to support the innovation cycle

Note. Phase I elements 3 and 5 related to graduate education were not included in this article.

that respondents used the "teaching" and "educational innovation" interchangeably. As a result, many of the examples present suggestions for enhancing teaching practices at respondents' institutions.

Within Curriculum and Pedagogy, faculty focused on professional development opportunities for themselves and for graduate students. Some faculty recommended that graduate students be introduced to educational research, pedagogy, and other topics of interest to future faculty. Some faculty noted,

> We do have an opportunity, particularly on the graduate level, to provide career enhancing seminars, workshops and activities (e.g., ethics seminars, teaching workshops, entrepreneurial workshops), that would contribute to training more well-rounded scientists and engineers. By providing these opportunities in a more formalized way to graduate students, we have a means to train more socially aware leaders and better educators in engineering.

Additional references to professional development opportunities by faculty within the context of Curriculum and Pedagogy related the connection of faculty to specialized educational innovation resources and the engagement of faculty in programs, professional societies with interests in educational innovations, courses, and local and national engineering education seminars and teaching workshops. A department chair response representing both Curriculum and Pedagogy and Reflective Teachers noted,

> This summer two faculty members are attending a workshop on active learning, one faculty member is attending a workshop on problem-based learning, and I have been working with a team from five universities developing materials on reflective learning with assessment.
>
> Our hope is that these ideas will be shared with all of our faculty over the next year. After hearing it presented at the national ASEE Conference we shared the ASEE-NSF report and comments with all of our department faculty.

Other examples of professional development opportunities within Reflective Teachers include the creation of teaching portfolios, the translation of industry experiences to the classroom, and the development of course materials.

Diverse representations of professional development related to educational innovations are found in the Policy category. Among the ways that stakeholders are creating policies to enhance professional development for faculty include new retreats and institutes that support faculty and graduate student engagement within innovations and teaching. While similar to many of the suggestions related to the development of curricula and pedagogy, responses in this category differ in that institutions are creating these initiatives in-house. For Policy, one dean provided several examples of policy changes that are occurring relative to educational innovations and professional development:

> Peer reviews of teaching and conversations about curriculum and how to improve teaching and learning are commonplace. Our university is highly assessment oriented, and every department goes through an extensive, data-driven assessment process every year. Our campus has established a center to help faculty improve teaching and learning, and a high percentage of our faculty members have taken advantage of this center's services. Our college pays all expenses of faculty members who attend regional or

> national workshops to improve their teaching. Two years ago, our college was instructed to update its promotion and tenure guidelines. This activity reinforced a broad view of research and scholarship that recognizes the value of pedagogical research and scholarship as well as discipline-based research and scholarship.

No educators referred to professional development and educational innovations from the perspective of Henderson et al.'s (2011) definition of Shared Vision.

Rewards Looking again to the descriptions of the Four Categories of Change Strategies model in Table 3, we also defined the categories in terms of rewards that might be offered to faculty to support educational innovation. Incentive examples mapped onto only two categories of the model: Reflective Teachers and Policy (Figure 3). Within the Reflective Teachers category, grants including engineering education-related grant opportunities (e.g., NSF CAREER awards), were noted as ways to acknowledge the contributions by faculty to educational innovations. Some respondents noted that their current systems already reward faculty innovation.

The majority of the remaining examples mapped to the Policy category of the model. Faculty, chairs, and deans identified numerous ways to encourage faculty to engage in educational innovations. These ways included traditional practices such as offering teaching awards and teaching release time. Among the less traditional ways to incentivize educational innovations included the creation of faculty positions in the area of educational innovation and the awarding of financial incentives such as corporate awards for innovative educational practices. One of the most prevalent areas of concern related to promotion and tenure expectations for faculty engaged in educational innovations. For Policy, one faculty group noted,

> As a department, we are changing the expectations of promotion and tenure (P&T) to include and value educational research as a legitimate branch of engineering research. We are not sure teaching will ever be "more valued," but we are helping to frame educational research. This year, we had two faculty members tenured and one promoted to full professor based on engineering education research.

Another example of policy adjustments made to acknowledge faculty contributions to both technical and educational areas was provided by a dean:

> Two years ago, our college was instructed to update its promotion and tenure guidelines. This activity reinforced a broad view of research and scholarship that recognizes the value of pedagogical research and scholarship as well as discipline-based research and scholarship.

Discussion

The ASEE Phase II survey collected data from engineering faculty, chairs, and deans on transforming undergraduate engineering education. Our mapping of the responses to the Four Categories of Change Strategies model helped to identify gaps and opportunities in engineering education innovation.

As revealed in Figures 1 to 3, many of the strategies and values of engineering faculty and administrators fall into the Curriculum and Pedagogy category – a class of strategies that prescribes specific pedagogies to individual faculty members. The responses also demonstrated an understanding that policies must be changed to support faculty in making these changes (Policy). Among faculty and deans, there was relatively strong support for actions such as rewriting promotion and tenure policies, acknowledging teaching excellence with awards, and funding seed grants. Some responses also fell into the Reflective Teachers category, related to faculty development, but with mixed levels of support. Traditional approaches such as external funding and teaching portfolios had good support among faculty and chairs. However, other approaches advocated by the Phase I report, such as training graduate students to do engineering education research and implementing the innovation cycle, were not well received by the faculty members who responded to those survey items (see Table 4, items 7b and 9). (There is some evidence in the written comments that respondents perceived these aspects of the report to be pushing an engineering education research agenda too strongly.) Many of the open-ended comments indicated an awareness of faculty development opportunities, such as workshops and teaching and learning centers, that respondents had considered taking better advantage of.

Few, if any, results fell into the lower right category (Shared Vision), for example, strategic planning. Respondents did not connect ongoing strategic planning efforts to discussions of the importance of teaching and education. We placed survey items related to learning environments at the center of all four categories in Figure 1 because they relate to specific curricula as well as vision and values. Laboratories, research, and industry experiences had strong support among faculty, who took great pride in their current programs (e.g., industry-sponsored capstone projects). Competitions, mentoring, and extracurricular experiences had mixed support. The Phase I report emphasized these as the strongest aspects of engineering education, but perhaps respondents had difficulty seeing how largely extracurricular experiences could be integrated into formal curricula required for all students. The least support was demonstrated for service learning, international experiences, and entrepreneurship. These, too, are difficult to envision implementing in traditional engineering curricula and require a strong commitment from faculty members. Developing a shared vision of the future of engineering education, including positioning the institution as a leader, would strongly support, if not be required to implement, these types of transformational changes.

Developing a shared vision can happen on many organizational levels: department, college, institution, and profession. The ASEE Advancing the Scholarship of Engineering Education initiative developed a shared vision by engaging faculty and administrators in discussions. All ASEE members were invited to participate in discussions at the national and regional section meetings during the year of dialogue. Several committees and meetings were organized to write the Phase I report. The Phase II survey engaged faculty, chairs, and deans in reflecting on how their own values and practices align with the recommendations of the Phase I report. In addition to encouraging dialogue, the survey provided important baseline data that may be used in the future to evaluate the impact of transformative change interventions. Engineering and other STEM education communities might consider similar approaches in the future as proactive interventions aimed at transformative change.

Readers may be concerned about potential biases in the creation of survey questions, the mapping of responses to an existing model, and conclusions that certain change approaches are not being advocated within the engineering education community. However, we had limited input into the recommendations of the Phase I report. The closed-form survey items were based on the recommendations embedded in the report, and the project's co-directors were deeply involved in the process of incorporating them into the survey. We did not consult the change-strategy model when developing the survey. The open-form responses were also directly mapped to the model and informed the placement of the closed-form items by providing additional detail about how respondents discussed these topics. The open-form responses that were not presented here also did not address the Shared Vision category. Finally, we presented our rationale within this article so that readers may judge the placement for themselves. The fact that the Phase I report and our survey did not include any items related to Shared Vision is more a reflection of the broader engineering education community than any bias on our part.

Finally, this study validates and extends the framework of the change-strategy model. That model was developed on the basis of published studies, which themselves could have been influenced by publication bias. For example, change efforts with evidence of success are more likely to be published, and certain types of authors are more likely to publish than others. Henderson et al. (2011) concluded that the majority of undergraduate STEM education change efforts focused most on the strategies associated with faculty and least on the strategies associated with administrators; this focus on faculty could also be explained by publication bias. This article validated the change-strategy model by applying it to quantitative and qualitative survey responses by engineering education faculty and administrators. We had similar results: specifically, that engineering faculty and administrators were considering items, though not specifically aware of the four categories, in Curriculum and Pedagogy, Reflective Teachers, and Policy – but not Shared Vision. Although it was beyond the scope of this article to map all of the strategies and theories used to frame change efforts in engineering education, we have demonstrated that the change-strategy model is robust in capturing the change strategies most cited among engineering education faculty and administrators.

Conclusion

This article further analyzed data from a survey that was part of a large-scale, U.S. engineering education change initiative with multiple components, including a year of dialogue and two reports. The survey invited faculty, chairs, and deans to reflect on their own engineering education practices and values. This approach was unique because it collected feedback from three levels and analyzed the responses of different groups. This survey provides important data to inform ongoing discussions of engineering education change and serves as a baseline for evaluating changes over time. For this article, we mapped the results to the Four Categories of Change Strategies model (Henderson et al., 2011), which combined quantitative and qualitative findings and helped identify gaps and opportunities in engineering education innovation. While educators have made advances in improving engineering education, there is still untapped potential for further advancement through the development of a shared vision with educational innovations for transformative change.

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