

AC 2008-859: MORE THAN GOOD CURRICULA: A GUIDE FOR CURRICULAR CHANGE AGENTS

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More Than Good Curricula: A Guide for Curricular Change Agents

Abstract

Each year, many engineering faculty members undertake curricular innovation projects, often with a long-term goal of the innovation becoming mainstream in their department, college, or institution. While the literature on curricular and pedagogical innovation is very large, the knowledge base on which engineering faculty members, who could be viewed as the essential curricular change agents, is smaller and scattered across different disciplines. This paper will synthesize research and practice on curricular change to offer an accessible knowledge base and guidance for curricular change agents. After the introduction, the paper will be organized in the following sections: (1) goals for change, (2) barriers to change, (3) foci for change, and (4) strategies for change.

Introduction

As an engineering faculty member, you may be in the midst of working on a curricular innovation or contemplating making a curricular innovation. In either case, you may be thinking that the curricular innovation on which you are working (or hope to be working) will eventually be broadly adopted across your department, college, or institution. However, issues that you face when developing your curricular innovation are almost entirely different from issues that you face when contemplating broader adoption of your curriculum. Curriculum development integrates subject matter expertise, research on how people learn^{1,2}, research on pedagogical innovations and practice³⁻⁷, as well as prior research on curricular innovations that have already been developed in your discipline (as well as others). It is also likely that you are bringing in other aspects and research in addition to these areas. However, when you are contemplating issues and processes of broader adoption, you draw on research and case studies in individual and organizational change. Research on change has drawn contributions from many different disciplines, including economics, history, political science, psychology, sociology, management, political science, education, and communication⁸. Often the literature on change is completely distinct and separate from the research that supports curricular innovation. Awbrey⁹ suggests that “[f]aculty members focused on research, teaching, and service are often not aware that general education reform thrusts them into the unfamiliar role of agents of cultural change.” Although change in engineering education differs from change in general engineering, her characterization is still relevant. Further, many engineering faculty members may be unfamiliar with research that might guide their efforts to achieve broader adoption.

This paper builds on an earlier framework for change¹⁰ to offer assistance for curricular change agents. In the following sections, we will offer suggestions in four areas: (1) goals for change (what is the desired end state of your change initiative?), (2) barriers to change (what will make it hard for you to reach your goals?), (3) foci for change (what parts of the system will you seek to change?), and (4) strategies for change (what is the big picture of how you plan to bring about the change?).

Goals

Goals for change convey expectations for desired conditions at the conclusion of a change initiative. Change agents should start with their goals for change, since clearly articulated, compelling, widely supported goals for change will facilitate explicit decision-making processes. For example, some engineering departments across the country are facing the challenge to reduce the number of credit hours required for their degree programs to meet legislatively or institutionally mandated limits¹¹. If the goal is stated as meeting a mandated credit hour limit, it can be easily achieved. If, for example, your current curriculum requires 132 credit hours and the mandated limit is 120 credit hours, then eliminating any three 4-credit courses will meet the goal. However, no faculty member would be satisfied with arbitrary elimination of three 4-credit courses. The reason is that the goal is not simply meeting a mandated credit hour limit, but the goal includes less well-defined and often less explicit criteria about retaining quality of preparation for the graduates. To the extent that these criteria can be made more explicit and less ambiguous, these criteria can support a decision-making process.

This example points out one of the characteristics of goals in academe: frequently goals in academe are ambiguous. As Kezar¹² writes “many commentators have suggested that higher education is an organized anarchy. Organized anarchies have inherently ambiguous goals...” Ambiguous goals allow diverse departments and colleges to claim consensus without agreement on concrete, actionable goals. However, ambiguous goals complicate planning for change and assessment of success of change efforts. Consider another example, a mechanical engineering faculty member who wants to implement the prototype of a thermodynamics course using problem-based learning. If the goal of a curricular change initiative is to put in place an engineering thermodynamics course with problem-based learning, then assessment of that goal can be done by asking whether the course with the required characteristics has been implemented. However, questions about the degree to which the course changes made a difference can be addressed only if new goals with respect to student learning, retention, or success are formulated. If these goals were articulated at the beginning, then alternatives to the problem-based approach could have been explored before launching the problem-based curriculum. Conversations about alternative approaches might have been contentious and seemingly unproductive, and delayed implementation of the first prototype, but the result might have been more widespread support for the course change, once it was implemented.

Goals for curricular change initiatives often fall into one of the following categories:

- Improve student performance in a particular course
- Improve recruitment: increase the number of engineering applicants and entering students
- Improve recruitment of underrepresented groups: increasing the number of engineering applicants and entering students from underrepresented groups
- Increase retention: increasing the percentage of students that are retained from entrance into engineering until graduation
- Increase retention of underrepresented groups: increasing retention of multiple underrepresented groups from entrance into engineering until graduation
- Improve learning with respect to existing program learning outcomes, such as content mastery

- Create new program learning outcomes and improve learning with respect to these new program learning outcomes. Examples might include appreciation and skill in addressing diversity and systems thinking.
- Change faculty conceptions or beliefs about learning

To the extent that the goal is articulated and attracts support, conversations then can shift to alternative approaches to achieving the goal. At this point, inquiry into the knowledge base of previous initiatives could inform conversations about alternatives that had been tried and the success (or lack thereof) that followed. For example, if change agents are considering alternative pedagogies as an approach to achieve their course goals, they may to investigate the literature that supports the efficacy of student-centered pedagogies^{3,4,13-39}.

Barriers to Change

Resistance to change is inevitable^{40,41}. Recognizing its inevitability, Mauer³⁴ encourages change agents to anticipate and address resistance in their plans, rather than be surprised at its occurrence and have to improvise. Change agents who are prepared to address commonly occurring barriers are likely to be more effective than unprepared change agents.

Research by Sunal et al.⁴² showed that faculty in their survey, which asked respondents to identify barriers to change, ranked “resources, time, and turf conflicts” as “very important” 60% of the time. Faculty members who are asked to teach a course with a new syllabus or consider whether to adopt an innovative pedagogical practice may perceive that they must invest significant time to implement these changes in their own courses, and they may be reluctant to use this time for course changes instead of other opportunities, which they might perceive as more valuable. To address this barrier, change agents should consider what types of resources might be developed that would save faculty time in learning more about and adopting the changes under consideration. Saving faculty time illustrates, in one example, important relationships and interconnections between curricular change and faculty development. Overlap between faculty and curriculum development will be explored more deeply in the section on foci for change.

If the change being considered may span more than one course, curriculum development then becomes the collective responsibility of the department (or whatever unit is responsible for the collection of courses). However, as Fisher, Fairweather, and Amey⁴³ report, there are tensions between collective responsibility for the curriculum and faculty autonomy:

- “The tension between collective responsibility and the system of individual faculty rewards;
- The tension between collective responsibility and the boundaries of academic freedom;
- The tension between collective responsibility and the faculty member’s desire to maximize his/her autonomy;
- The tension between collective responsibility and faculty collegiality.”

The challenges inherent in the curricular change process often lead to conversations that default to issues of content. This is understandable because it reflects faculty interest and expertise in general and their point of frustration in terms of student performance. It also demonstrates their

mental models and ladders of inference⁴⁴ as well as the curse of knowledge⁴⁵ – all of the automatic and largely invisible patterns of thinking in which experts operate become implicit goals for change. However, learning is recognized as extending far beyond traditional content mastery (e.g., it includes understanding of concepts, the nature of science, and organization of knowledge within the discipline), and is reliant upon educational structures and faculty practices of teaching¹. Conversations about why students are not demonstrating appropriate mastery of critical content knowledge are not productive unless faculty members are able to look beyond what they are or are not seeing in terms of student performance to larger questions such as “where does my course fit in the curriculum,” “what are the courses before and after mine asking students to do with what they are learning,” and “what other ways can I convey/assess critical content knowledge?” These questions often lead to surfacing of tensions between collective responsibility and maximization of autonomy, barriers of academic freedom, and even faculty collegiality.

Large-scale curriculum change agents should recognize which of these tensions might be strained by potential curriculum changes and be prepared to address these tensions through conversations with department heads and other administrators, review of future teaching loads, development of appropriate recognition and rewards that might be associated with participation in the curriculum change initiative at one or more stages, and conversations across the department about course and curriculum ownership⁴³.

Dancy and Henderson⁴⁶, through interviews with physics faculty, some of whom had beliefs that were aligned with theories emerging from physics education research, but had not adopted research-supported pedagogies, found several structural barriers to adoption of research-supported pedagogies. These included anticipated resistance from students, the one-size-fits-all schedule of courses that meet three fixed-length times a week for a semester, amount of material that is expected to be covered in a single course, department norms that support traditional approaches, and lack of time (see above). Student resistance to pedagogies that expect more active participation in class has been reported elsewhere^{47,48}. Cooper et al.⁴⁸ offer the following strategies to address anticipated student resistance: clarify changing expectations before and during implementation of new strategies, create meaningful activities that encourage students to process information in different ways and yet that are at an appropriate level of difficulty and complexity, and clarify expectations for each learning activity. Felder and Brent⁴⁷ list several student complaints about innovative pedagogies and offer ways in which faculty members might address each area of resistance. Felder and Brent⁴⁹ cite content coverage as a frequently asked question in their workshops on effective teaching and offered one way to address this issue: put significant material that you would cover in lecture into class handouts and announce that you will not go over in detail material in the handouts, but that students are responsible for material in the handouts⁴⁹. This is one way to cover material and create class time for alternative activities that may lead to deeper learning. In a series on frequently asked questions, Felder and Brent address several questions that faculty members raise about implementing alternative pedagogies: where is the evidence that they work⁵⁰, content coverage⁴⁹, large classes⁴⁹, groupwork and distance learning⁵¹, student hostility to teaching methods that require them to take more responsibility for their own learning⁵², low student motivation⁵², how to design fair tests⁵³, evaluating teaching⁵⁴, and persuading other faculty to use nontraditional methods⁵⁴. Finally,

department norms for instruction are linked to the next possible source of resistance, lack of alignment with organizational culture.

As demonstrated by Kezar and Eckel⁵⁵, the culture of an institution influences success or failure of change initiatives. Merton et al.⁵⁶ studied two different change initiatives within a single institution and show how the initiative that led to a more sustainable curriculum aligned better with the culture of the institution. As these examples illustrate, change agents should “realize that the culture of the institution (and institutional type) affects change” and seek a better understanding of the culture of the institution. Although organizational culture can be a somewhat nebulous, hard to grasp concept, several researchers have provided useful tools. Schein⁵⁷ portrays culture in three levels: artifacts and actions that could be observed; values and behavioral norms that are frequently mentioned by organizational leaders, and shared, underlying assumptions that are rarely mentioned, but direct decisions because they were influential in the early success of the organization. Bergquist and Pawlak⁵⁸ assert that cultures of institutions fit into one of six types: collegial, managerial, developmental, advocacy, virtual, and tangible. Curricular change agents might review these types and ask which their organization most closely resembles and use strategies that Kezar and Eckel⁵⁵ showed were effective in these types of institutions. Finally, Tierney⁵⁶ offers a six-element framework: environment, mission, socialization, information, strategy and leadership in which to set the culture of the institution. These structures can be the basis for a self-diagnosis or external culture audit to help change agents better understand their organization and how various alternative initiatives are likely to play within the culture.

Foci for Change

Foci for change are entities to be altered to achieve espoused goals. Often, change agents focus on curricula, in the belief that if the curriculum is revised, then goal achievement follows. For example, change agents may have settled on a goal of increasing retention in engineering after one year, especially for women and underrepresented minorities. Then, the question follows: What is going to be changed in order that first-year retention will increase? Curricular change agents respond by asserting that the curriculum must be changed⁶⁰: some topics must be added, other topics must be omitted, remaining topics must be rearranged, and projects must be added, and/or more recent approaches, such as Model-Eliciting Activities should be used^{61,62}. If their description of curriculum includes pedagogical approaches, then active learning^{3,63} must be introduced, cooperative learning^{3,13,64} should be applied, problem-based learning^{4,65} should be tried, and/or project-based learning should be used. Curricula change alone may be insufficient to attain the goal. In reflecting on their eleven years of experience with curricular innovation and institutionalization, leaders of the Foundation Coalition “agreed that curricular change was much less about changes to curricula and much more about changes regarding learning and teaching among faculty members”⁶⁶. Experiences of the Foundation Coalition support the assertion that efforts to change the curriculum should be broadened to embrace faculty development. Henderson, Dancy, and Beach⁶⁷, in their study of change in undergraduate STEM education, suggested that there have been three separate foci for change: curriculum, faculty development, and organizational structures and policies. Further, their analysis of research publications associated with each of the three foci indicated no overlap among research on the three foci: articles associated with one focus do not reference articles in the other foci. Finally, critiques of

efforts to change STEM education through pursuing primarily one change focus: curriculum, faculty development, or organizational structures and policies, reveal that these efforts have not had widespread influence^{12,68-71}.

As a result, curriculum change agents should consider expanding their design space of alternative foci beyond the three current choices: curriculum, faculty development, and organizational structures and policies, which will be referred to as isolated foci. Additional options that readily present themselves are combinations of the three isolated foci: curriculum and faculty development, organizational structures/policies and curriculum, organizational structures/policies and faculty development, and faculty development, curriculum, and organizational structures/policies. The importance of the combination of all three isolated foci was revealed in a study of the processes of curricular change across the Foundation Coalition⁶⁶. Here, in the fourth change model, change agents first faced the challenge of developing new curricula (curriculum focus), then faced the challenge of persuading faculty to adopt the new curricula and equipping adopters to teach within the new curricula (faculty development focus), and finally recognized the challenge of altering organizational structures and policies that worked for the older curricula, but did not support the new curricula (organizational structures and policies focus). Although researchers suggested that the fourth change model that emerged in the later years of the Foundation Coalition was not the final answer, its existence demonstrated the value of addressing all three isolated foci.

Addressing combinations of the three isolated foci through a coordinated change initiative breaks new ground. There are few, if any, examples that might provide guidance for a change agent. However, there is a substantial literature on each of the isolated foci^{12,70,72}. Further, past experience suggests that addressing a single isolated focus is unlikely to lead to broad, institutionalized change.

In the absence of documented exemplars on which to draw, consider a specific example: a small group of faculty members from an individual department are interested in improving a core engineering course in their curriculum, e.g., engineering thermodynamics. It is a required course, taken (according to the catalog) by students late in their sophomore year or early in their junior year. Two trends have aroused the interest of this group of faculty members in engineering thermodynamics. First, the success rate of students taking this course for the first time is lower than this group of faculty members considers acceptable. Second, faculty members who are teaching the subsequent course routinely complain about the lack of understanding of key concepts. The group of faculty members, who will be referred to as change agents, decides that significant revisions to the curriculum for engineering thermodynamics are necessary. However, they decide that major curriculum revisions will be inadequate to lead to an institutionalized program to change the two trends. They want to initiate three parallel thrusts: curriculum development, faculty development, and organizational structure and policy change. Faculty development will depend, in part, on stirring interest among the rest of the department faculty in the shortcomings, as they see it, in the engineering thermodynamics course. For this purpose, they select a department meeting to review what is happening in engineering thermodynamics. To actually collect data on the success rate of students taking thermodynamics for the first time, they would work with the college administration to track students, identify each student who has taken thermodynamics for the first time and determine what each first-time student earned as a first grade. With this data, they document the success rates of first-time students over the period

of several years. Next, they review the literature on thermodynamics instruction and learn and many researchers have documented misconceptions before taking thermodynamics⁷³⁻⁷⁶. Third, they talk with faculty members who teach the follow-on course and obtain more detailed descriptions of the deficiencies they routinely mention. They open the meeting by presenting this data, and solicit analysis of the severity of the problem as well as suggestions for courses of action that might address the situation. They compile the results of the meeting and send the report back to the department faculty. With this foundation, they believe they have set the groundwork for action by the department to address the curriculum, work with faculty who might teach thermodynamics, and changes in departmental policies (such as requiring all faculty members who teach thermodynamics for the first time to take a seminar on what the department has learned through its approach to teaching thermodynamics). Continued development of this hypothetical vignette might illustrate how a change initiative might simultaneously address multiple foci. At this point, the value of the vignette is to show that multiple foci could be addressed concurrently in a change initiative.

Strategies for Curricular Change

A change strategy is an overall plan for how the change will occur. Curricular change strategies seem to come in two varieties: (i) prototype first, and (ii) full-scale deployment. In the prototype first strategy, change agents develop the new curriculum and then offer it to a fraction of the students for whom it is ultimately envisioned. There are two sub-varieties of the prototype first strategy: (a) show that it makes an improvement, and (b) work out the kinks.

The purpose of the first sub-variety is to demonstrate that that prototype makes a difference with respect to the stated goals in order to convince other faculty members that changes should be made. As pointed out by Froyd, Penberthy, and Watson⁷⁷, the first sub-variety provokes confusion between the role of the prototype curriculum as an educational experiment (i.e., are certain hypotheses about the influence of the prototype curriculum on student performance supported or not?) and the role of the prototype curriculum as a precursor for broader deployment (i.e., are the implementation kinks worked out?). As Clark et al.⁶⁶ discovered from their study of curricular change processes across the Foundation Coalition, the prototype never provides sufficient evidence to justify broader deployment across the spectrum of faculty members responsible for approving broader deployment. A prototype, by its nature, starts with only a segment of the population. Therefore, skeptics and opponents could always question assessment data and ask whether similar results would be obtained if implemented on a larger scale, particularly for segments of the student population that did not participate in the prototype curriculum. For example, a first-year curriculum, implemented as a prototype for calculus-ready students, would not offer data on its efficacy for pre-calculus students. A prototype curriculum could never address these questions. Another challenge of a prototype curriculum is one of ten processes that were identified by Senge et al.⁷⁸ and hinder change. This challenge occurs when the energy of the change agents becomes transformed into the belief that they have the right way. The emerging we-versus-they confrontation hinders broader deployment of the prototype curriculum. Further, if the change agents implement the prototype curriculum, it does nothing to support the development of the faculty members who might have to teach the curriculum in broader deployment; that is, from a change focus perspective, prototype curriculum implementation by the change agents does not support faculty development. This is one reason

why the mathematics department at Harvey Mudd College, when implementing a new mathematics sequence, asked faculty members who did not develop the new sequence to teach it for the first time⁷⁹. The second sub-variety of prototype first strategy uses the prototype curriculum to uncover problems or potential problems in the implementation of the new curriculum. In this case, stakeholders assume that the new curriculum will be deployed at full scale, assuming no large, unanticipated problems occur, and the prototype is used to merely to prepare faculty and materials so that the new curriculum can be fully deployed. If a combination of curriculum developers and faculty members who did not actively participate in the development of the new curriculum teaches the prototype curriculum, it can be an opportunity for faculty development.

The second variety of curricular change strategies is full-scale deployment. In this strategy, the new curriculum is deployed for all students in its first implementation. Full-scale deployment avoids many of the issues associated with the prototype first strategy, but it raises the stakes if the new curriculum has initially poor results, because the implementation influences a much larger number of students. Also, the number of faculty members who have to be prepared to teach the new curriculum in its initial implementation may be much larger, and this calls into question the extent to which change agents have prepared plans to address faculty development prior to initial implementation. Another issue with full scale implementation is determining comparison groups if stakeholders are interested in questions about the extent of the difference caused by the implementation of the new curriculum. Recognizing the tradeoffs involved in both strategies, the Department of Electrical Engineering at Oregon State University selected the full-scale deployment strategy for its Platforms for Learning™ initiative⁸⁰. Published results show overall satisfaction with its strategic choice. Both prototype first and full-scale deployment have advantages and disadvantages and change agents are encouraged to consider each carefully before making a final decision.

The principal aim of faculty development strategies is to promote and support faculty members to participate in faculty development activities to the extent that they are encouraged and stimulated to revisit their beliefs about learning and teaching and approaches to teaching and consider alternatives. A sophisticated range of faculty development activities⁸¹: faculty learning communities^{82,83}, workshops that build activities around adult learning theory, in which adult learners have substantial prior knowledge and apply sophisticated and complex self-directed learning capabilities⁸⁴⁻⁸⁶, and extensive reading resources, has been developed by researchers in faculty development. Assuming change agents are prepared to deploy a spectrum of faculty development approaches, their principal challenge is to construct methods and environments so that participation in these activities is an accepted norm.

If curricular change agents select a combination of the isolated foci: curriculum, faculty development, and organizational structures/policies, then more strategies may become available. Since selection of such change foci has been rare in prior change initiatives, the set of strategies that has been developed to date is very small, and change agents have opportunities to be creative in their development of strategic options that would concurrently address multiple isolated foci.

Conclusions

There have been a number of stories published on the process of change in higher education that illustrate the complexities and nuances that change agents should consider in selecting their goals, identifying the barriers, choosing their foci for change, and preparing their strategies.

Examples include:

- Campbell, Elliot, and Gladding⁸⁷ chronicled the process of revising the introductory physics sequence at the University of Illinois at Urbana-Champaign
- Clark et al.⁶⁶ studied the process of change across the six institutions participating in the Foundation Coalition and documented how the strategies through which they envisioned that curricular change would occur evolved over the life of the Coalition.
- Merton et al.⁵⁶ compared and contrasted two large-scale curricular change processes at the same institution.
- Beichner et al.²⁷ describe elements that were integrated into introductory physics courses intended for large enrollments.
- Margollis and Fisher⁸⁸ describe the initiative at Carnegie Mellon that increased number of women enrolled in computer science through curriculum changes and other processes.
- Kezar and Eckel⁸⁹ explored the process of institutional transformation at six higher education institutions and offered five elements that curricular change agents should integrate into development of their strategies: senior administrative support, robust design, staff development (one of the three isolated change foci), and visible actions. Institutional transformations that are studied are larger in scope than changes envisioned by curricular change agents, but the narratives and lessons extracted from the research may be beneficial to curricular change agents.

One of the challenges in this paper has been to synthesize these stories and other research on curricular and organizational change into guidance for future curricular change agents. Based on our analysis of this literature, curricular change agents need to be prepared to accomplish the following

1. Construct, across the group of stakeholders, clear, widely supported goals for the change initiative
2. Anticipate barriers likely to arise in the change process and be prepared to work constructively with the barriers
3. Consider a wider set of options for the focus of the change initiative other than just the curriculum
4. Use the experience of other curriculum change initiatives to prepare a strategy that avoids, as much as possible pitfalls of previously implemented strategies. Strategies that address a combination of isolated change foci are needed.

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