Going Beyond "What Should We Do?": An Approach to Implementation of Innovation and Entrepreneurship in the Curriculum

Introduction/Abstract

In the engineering disciplines, "agile" approaches are most often associated with product development, particularly in the software arena. The approach is most useful for addressing challenges that are complex, require many people, and in which there is a high degree of uncertainty about the best approach.[1] This set of conditions holds true far beyond product development.

One such scenario is that of planning and implementation of organizational interventions –an environment in which "strategic planning" is often the tool of choice but one which is ineffective in a networked (rather than hierarchical) context. An alternative approach described in this paper is "strategic doing". As in agile product development, the approach uses iterative cycles of implementation, learning and reflection, and improvement, with a focus on rapid experimentation and gradual scaling up of solutions. While not designed for educational settings, the use of strategic doing in such environments is growing. Some recent examples include deployment at individual universities seeking to reform their curriculum, as a technique for students to better organize teams in classes like capstone design, the transformation of academic departments, and the formation of cross-disciplinary research teams to address "grand challenges."

This paper describes the process and its application to engineering education, specifically in an effort to increase the range and quality of innovation and entrepreneurship offerings for undergraduate engineering students.

Program description

The Pathways to Innovation (Pathways) program is an initiative of the National Center for Engineering Pathways to Innovation (Epicenter), funded by the National Science Foundation and managed by Stanford University and VentureWell.[2] The goal of Pathways is to make high-quality innovation and entrepreneurship offerings available and accessible to undergraduate engineering students, through two strategies: faculty development and institutional change. Teams of faculty and administrators from 50 institutions participate in the program in three cohorts (chosen in a competitive process in three successive years).

Participating schools are four-year US institutions with engineering programs, but beyond that do not have any specific profile: they include both public and private schools; range from fewer than 100 undergraduate engineering students to more than 9,000[3]; are in urban, rural, and

suburban settings in 32 states; and include both research-intensive universities and liberal arts colleges. Several are minority-serving institutions.

The Pathways program is a multi-faceted initiative that includes several different components to help schools fully embed innovation and entrepreneurship into the undergraduate engineering experience. Schools start with a comprehensive "asset mapping" activity designed to develop a fuller and collective understanding of the school's current I&E ecosystem.[4] Following the asset mapping, teams participate in both in-person convenings and online gatherings over a 1-2 year period. In general, program activities serve one of two purposes (although there is overlap): 1) information and coaching about specific kinds of offerings to expose students to I&E (eg, design thinking, makerspaces, pitch competitions, student orientation programming) or 2) guidance and support in the process of making change on their campus, without respect to the specific content of the educational intervention. This paper focuses on the second goal and the methodology used in pursuing it.

Pathways is designed as a context-specific initiative; that is, there is no one pedagogical approach or set of offerings each school implements. Rather, schools are encouraged to learn about a wide variety of approaches and ideas and to choose what fits their own strengths and needs. Even as schools are choosing their own strategies, however, the program activities are designed to foster a strong "community of practice"[5] that can persist beyond the program to support team leaders and members in institutionalizing their work.

Origins of strategic doing

Strategic doing emerged as an alternative to traditional strategic planning, which itself has roots in logistics operations during World War II, and was codified in the early 1960s.[6] Strategic planning is characterized by several features:

- A separation of thinking and doing, in which a small group of top managers designs the plan, and those lower in the organization execute it;
- An assumption of linear movement, in which one step is completed before moving to the next;
- An expectation that the environment in which the plan was designed will remain essentially stable over the planning horizon;
- A process in which analysis must be completed before decisions are made.[7]

While these features may create clarity, they do not allow for a more dynamic environment. Recognition that change is the primary hallmark of the modern economic and social climate – at least in many sectors – led to growing dissatisfaction with strategic planning and searches for alternatives. In particular, the transition to knowledge as the foremost ingredient to create value (rather than the value of a raw material, large pools of labor, or large manufacturing capacity)

necessitates a different approach to strategy. Knowledge moves along networks of relationships and is unbounded: it can travel easily between organizations.

Strategic doing also borrows from several other approaches to change, including appreciative inquiry and asset-based community development[8], that have become commonplace over the past several decades. The primary contribution to practice of these approaches is a shift away from a "deficit" model – that is, a starting point of identifying problems and a lack of resources – to a model rooted in assets that can be applied to help achieve a desired outcome. Under the approach, assets are broadly defined to include financial, physical, human or social capital. The assets reside in the collective knowledge of the network of people addressing an issue. Using this starting point, strategic doing then provides the process by which this knowledge is leveraged to mobilize and coordinate various assets to address the challenge under consideration.

Strategic doing was originally designed for community and regional development projects, often undertaken with a public land grant institution helping guide the work (land grant institutions were designed with this kind of public outreach in their original charter). These original efforts led to many successful initiatives.[9] As the universities involved became familiar with the approach, the participating administrators and faculty realized that there were internal applications for the approach and began experimenting with its use. To date, faculty or staff from more than 70 institutions have been trained in strategic doing protocols and are deploying the approach both in engineering education settings and beyond.

Description of strategic doing

Strategic doing is a process or discipline for groups which come together to address a complex problem for which there is no obvious or pre-determined solution. The challenges are inherently complex and dynamic. Solutions will ultimately require the efforts of a number of people from different operating units, departments, or organizations. In short, a new network of relationships must be developed and galvanized for action.

The process is "agile" – that is, it is designed to accommodate a changing environment in which frequent adjustments or changes of direction will be needed. The term "agile" is borrowed from the software design industry and arose when those firms sought to reduce the time needed to bring new and better-quality products to market. In agile design, work proceeds incrementally, with frequent testing by actual users and iterative improvements. As issues or new requirements become apparent, the product can be improved within the development process – rather than waiting for the next version of the product to incorporate new features or capabilities. Because the process is incremental, many people can be working toward the same goal. If they begin to work at cross purposes, friction will quickly become apparent and can be addressed.

Organizations – including academic institutions – tend to approach the need for change in much the same way as "old-school" software firms. There are a series of meetings by working groups

or task forces, in which a small group of people investigates current challenges and explores forecasts for what will be needed in the next 5-10 years. The group picks some set of goals or strategies or programs they think will address those needs, and then develops a detailed implementation plan that directs people (usually not the same people that are in the planning group) to put those strategies into action over that time period. Then the planning group disbands, its work "done." The initiative may or may not be called "strategic planning," but the characteristics are much the same.

The problems with this approach are many, as anyone involved with strategic planning in higher education can attest. A primary issue is that identified earlier: the predictions of the future environment may be wrong, either because conditions change or because assumptions were incorrect in the first place. Three other factors also make the approach unsuccessful: 1) the implementers have not been part of the planning process, although they have critical information to share; 2) as implementation begins, it may become apparent that a particular strategy does not work and thus all of the follow-on work laid out in the plan is obsolete; and 3) perhaps most critically, a "plan" cannot in and of itself make anyone implement anything – especially if the people who wrote the plan are not the same people who need to implement it.

As an agile approach, strategic doing approaches the planning/implementation challenge differently. In strategic doing, the term "strategy" is defined clearly and simply: A strategy answers two fundamental questions: where are we going? and how will we get there? To answer these two simple, but not easy questions, the strategic doing process focuses on answering four, questions. Groups use these four questions (shown in Figure 1) to move them quickly into action in small, incremental steps toward a measurable outcome:

What could we do?	What are all the opportunities before us that would build on our current assets?
What should we do?	Which of those opportunities provides the most value right now (defined as a combination of impact and ease of implementation), and how would we know if we succeeded?
What will we do?	What small project could those of us currently involved complete that would move us toward that outcome?
What's our 30/30?	When will we come back together to review what we've learned and done in the past 30 days, and plan for the next 30?

Figure 1: Strategic doing questions

These questions form the scaffolding upon which the team can construct its strategy. Their brevity promotes what Eisenhardt and Sull call a "strategy of simple rules", which is critical in a quickly changing environment, rather than gaining advantage by exploiting a stable resource or market position.[10] While the term was originally coined to describe how successful technology

enterprises operate, the environment for higher education in the 21ˢᵗ century can certainly be described as uncertain, if not chaotic, and the need to quickly respond to opportunities as they arise no less pressing.

As in agile software development, in strategic doing there is a shared understanding that the group will learn as they go and adjust– sometimes in small ways, sometimes in large strategic "pivots" – their activities accordingly. Small projects undertaken serially provide an opening for this kind of learning. Additionally, the group's work is explicitly an "action plan," with the actors the group members themselves, not a group of positional leaders who are deciding on a direction and then telling others to implement.

Rationale for using strategic doing in Pathways

Strategic doing was selected as a key tool for Pathways teams for several reasons:

Focus on process: A common refrain in engineering education circles is some variation of "we know what to do, why doesn't it happen?" There have been countless initiatives and millions of dollars spent to identify existing effective approaches to engineering education and to design new approaches. As a result, there are many exceptional individual engineering faculty members at institutions in every corner of the nation and globe. However, widespread adoption of effective practices remains elusive.[11] Clearly, it is not enough to just help engineering programs (and their faculty) understand what to do – they also need help and new tools to figure out how to make change happen. Teaching administrators and faculty the strategic doing approach gives them such a tool, and ongoing support within the program helps them make using the tool a collective habit.

The network as the unit of change: Most university leaders (as is true in industry) have an understanding of change management rooted in a "command and control" vision of the way organizations function. That is, positional leaders (be they presidents, provosts, deans or department chairs) occupy upper levels on the organizational charts and should thus be able to tell those below them what to do. However, an honest assessment is that things rarely happen in this fashion. Particularly in academia, individuals have tremendous agency and can determine their own actions.[12] A more accurate vision is that of a network – there is a web of relationships along which communication and influence move. Change that goes beyond individual faculty members needs to be undertaken with this structure in mind. Strategic doing was explicitly designed for this kind of environment, in which multiple actors want to work together but none of them can impose activity on their fellow group members.

Alignment with scholarship: The Pathways program was preceded by a literature review that explored effective approaches to curricular change. While there were no models that were directly adoptable for the Pathways program, several more general principles were identified that informed the choice to use strategic doing: the need to focus on the systemic nature of making change; the need for a participatory (rather than exclusionary) process; the importance of short-

term successes and a regular reporting process to build engagement; and the need to build interventions around the specific environment.[13]

Potential for growth: The mandate of Epicenter was to spur multi-faceted, widespread change within each institution, in a short period of time (no more than 2 years, and for schools in later cohorts less). This ambitious mandate required a different model than what is often customary in engineering education efforts, that is, professional development workshops for at most a few individual faculty members at each institution, focused on a constrained topic – usually the curriculum in a small number of courses - with limited follow-up. Pathways called for an approach that would enable many faculty members to be brought on board to the change efforts, working on many different kinds of interventions for students – and to do so in an accelerated timeframe. The strategic doing model assumes a small core group at the beginning of the effort, working on a small incremental change. As the group experiences success, other people voluntarily "opt-in" to the process. Both the networks and the scope of work grows.

Application in Pathways

Strategic doing is introduced to the Pathways teams at a one-day team leader orientation event. The event equips team leaders for the work ahead, in addition to exposing them to emerging research in engineering education and some efforts underway at other schools. Exemplars include both schools already in the program and other national models.

The strategic doing game -- The introduction to the approach begins with a simulation game, in which the group divides into small teams of 5-8 people around tables, and a set of role cards is provided for team members to choose from. Roles are those similar to those that teams may choose to engage back on their campuses: faculty at different levels, administrators with various roles, students, and alumni and community leaders. The role cards include some information about attitudes or values, as well as a set of assets – resources, relationships, skills – that the person could choose to offer up to the group.

The hypothetical scenario for each table is the same: agree together on a way in which an empty building could be used to strengthen engineering, and develop an action plan for the first 30-90 days of implementation. Teams are provided with a set of documents (called a strategy pack) that guides them through the process; each team is led by a "table guide" who has used strategic doing previously (usually a team leader from a school already in Pathways). The table guide's role is to maintain tight focus on the questions asked in the guiding document: what could we do? What should we do? What will we do? When will we regather to check in on progress? While the time is short (approximately 1.5 hours), each table is able to quickly decide on a course of action and develop a specific action plan for how that course could be pursued at the outset. After the game, the group debriefs and discusses the experience, with a focus on the key role of the table guide – the role each team leader will take at their institution.

The team workshop -- Approximately a month later, team leaders bring their teams to a two-and-one-half day planning workshop, which again combines learning about exemplars and strategic doing. Before they arrive, the teams have completed a detailed map of assets on their campus. Over the course of about three hours, each team begins with this map and completes a pack of workshop exercises. They use the assets on their campus and their own evaluation of various opportunities to choose a particular outcome to pursue, a "pathfinder project" to move them toward their outcome, and a specific plan of action for the first 30-90 days. Teams are paired to present their initial strategy to one another. They gather feedback using a provided rubric, and then spend another hour revising their initial plan and then transferring the information to a one-page summary called a "strategy map." Thus, by the end of the workshop, each team has a very specific charge for what it will do back on campus, including specific tasks for every member of the team and a scheduled follow-up meeting.

Check-in calls -- After the workshop, the team leaders attend a series of monthly calls for six months, with 3-5 teams represented on each call. Before the call, they are expected to have at least one meeting with their team and to jointly complete another map. In other words, each month they complete a new iteration of their strategy with any adjustments based on the results of their work thus far. During the call, each team leader presents their map and gathers feedback or advice. While the teams only have one collaborative project when they leave the planning workshop, they quickly expand the scope of their efforts and recruit new members onto their team. After the first six months, the calls become quarterly check-ins, but the format is largely the same.

Results

The strategy maps submitted by the teams at the monthly and quarterly calls, along with the group discussions provide a large data set about the kinds of interventions the teams are pursuing, the pace at which they are proceeding, how they are learning and adapting to results, and the challenges they are encountering along the way. The calls are recorded for later reference.

The numbers and types of interventions being pursued by teams and their pace of work are captured as quantitative data during each call and subsequently aggregated. The number and type of interventions are presented in a series of monthly charts with the number of efforts for each type of intervention as well as how many have been completed vs. those still underway. The pace of the teams' work as an aggregate is presented in a set of line graphs with each type of intervention shown as a separate line.

Interventions are classified using the taxonomy shown in Figure 2:

Category	Description	Example
Courses	Efforts to either design a new course or to substantially revise an existing offering	Re-organizing an introductory engineering course around a set of real-life scenarios and the use of design thinking
Credentials	Efforts to introduce a new program available to undergraduate engineering students	A major, minor or certificate in innovation engineering
Makerspaces	Efforts to launch or substantially expand a space on campus in which students can work together to design and/or build	A new space within the school's library, outfitted with informal group workspace as well as 3D printers and other tools
Informal learning	Efforts to provide learning experiences that do not offer course credit	"Pop-up" workshops that teach students how to use the tools in a makerspace
Competitions	Efforts to launch or substantially expand an event for students to demonstrate their innovation and entrepreneurship skills	A pitch event in which students present startup ideas based on prototypes they have designed and built
Infrastructure	A wide-ranging category that captures efforts that provide supporting resources, including physical assets and policy changes	A new university policy that clarifies the circumstances under which students can control the IP for products they invent
Consolidations of I&E	Efforts to launch a centralized home for I&E efforts (both physical and virtual) throughout the college of engineering or the entire university	A new Center for Entrepreneurship on campus.

Figure 2: Taxonomy of Interventions

 Figure 3 shows the status of the work of the 24 teams in the second cohort of the program, one year after their team workshop.

	Interventions Completed	Interventions still in development	Total	Potential impact*
Courses	25	37	62	39,269
Maker spaces	11	15	26	27,192
Credentials	2	20	22	23,090
Infrastructure	34	27	61	44,620
Non-credit learning opportunities	25	20	45	35,377
Competitions	12	14	26	29,040
Consolidations	4	5	9	15,122
Total	**113**	**138**	**251**	

* Matriculated undergraduate engineering students (US Department of Education, 2014)

Figure 3: Interventions undertaken by teams by category

The 24 teams had launched a total of 251 interventions since their planning workshop in February 2015, with a mean of 10.46 interventions per school (maximum 3, minimum 22, median 10). 113 of these were completed, with another 138 still underway. Courses were the most frequent type of intervention, with non-credit learning opportunities also well-represented. Partly because of the broad nature of the infrastructure category, those types of interventions were also very popular.

Figure 4 shows the line graphs demonstrating the pace of intervention introduction for these same 24 teams:
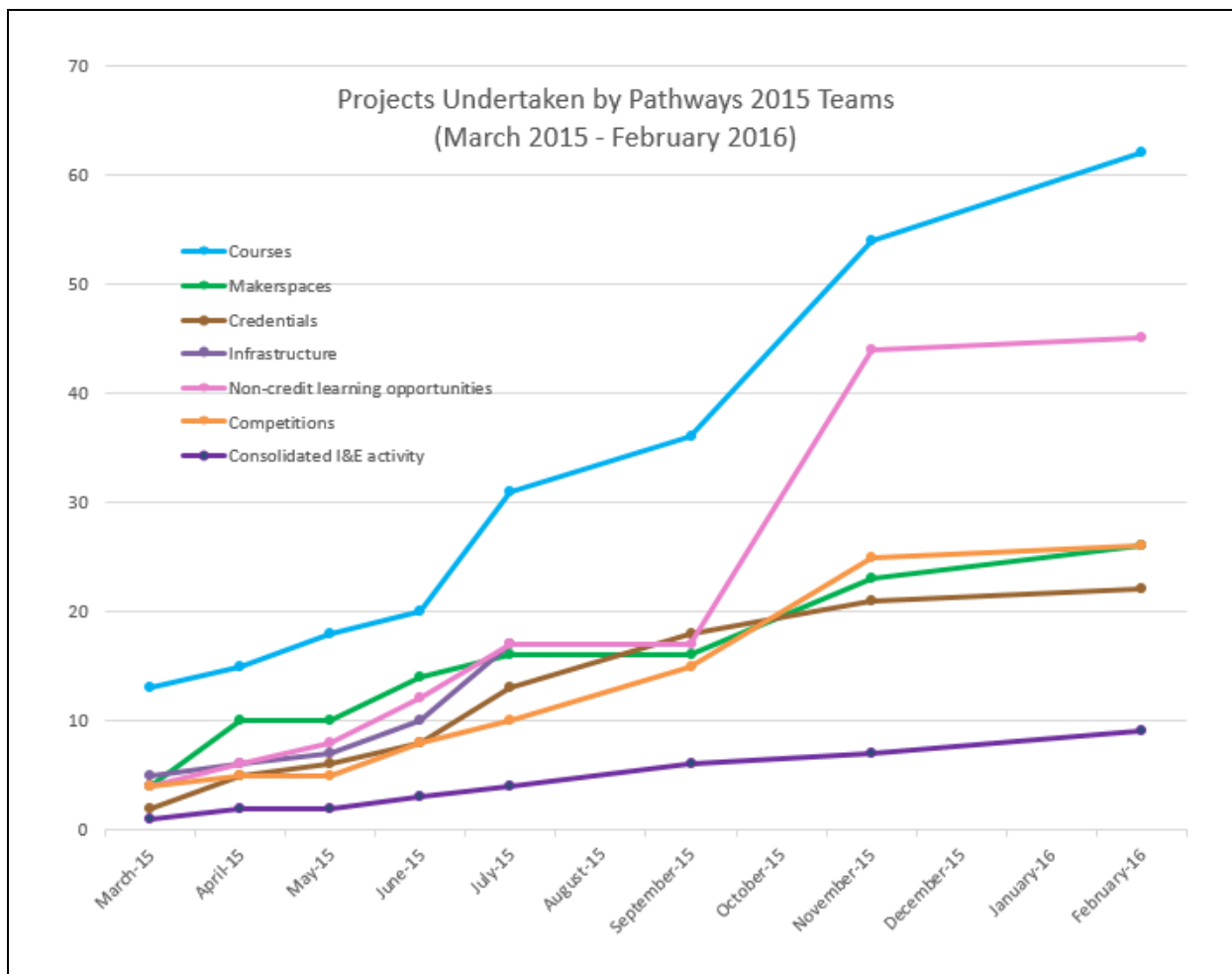
Figure 4: Interventions undertaken by teams over time

The figure illustrates several aspects of the teams' work:

There was consistent growth in the number of interventions undertaken, and the pace quickened for the schools over the course of the seven months. This result is consistent with the principle that initial success helped teams recruit new members, which in turn expanded the capacity of each team to take on new projects. This is also consistent with the feedback gathered by the external evaluator, described below.

Different kinds of interventions showed different trajectories. For example, while the number of centers increased, each campus could only deploy this kind of intervention once so growth was modest, while the potential for non-credit learning opportunities is very large and could grow much more quickly. Looking at only completed interventions sheds additional light on these trajectories, as shown in Figure 5. While the pace was slow for the first four months, three types of interventions "took off" with the start of the fall term: courses, non-credit learning

opportunities, and infrastructure. Other kinds of interventions, such as makerspaces and credentials, take longer to come to fruition and thus show a more modest trajectory.

Completed Interventions
March 2015 - February 2016

Figure 5: Completed interventions undertaken by team over time
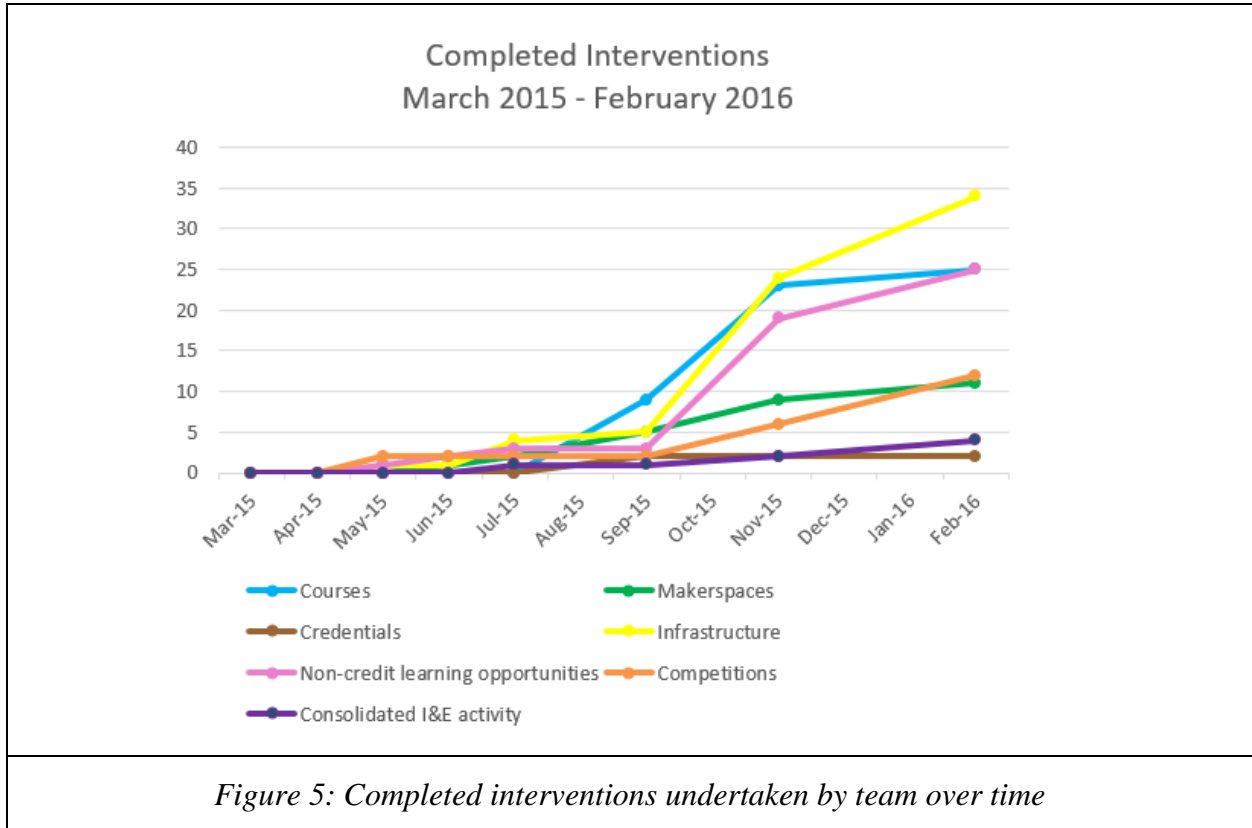
External Evaluation Data

In fall 2015, a group of team leaders and members participated in interviews with the project's external evaluator. The focus group protocols covered multiple aspects of the Pathways program including the strategic doing process. Focus groups were conducted using a video conferencing software and lasted no more than 45 minutes. Participants were also verbally administered a brief survey where they could rate the extent to which they agreed with a series of statements. While the sample is small (six leaders, seven members) from thirteen institutions, the feedback about the strategic doing process suggests a positive experience. Team leaders were specifically asked about their experience with having monthly check-in calls. One hundred percent (100%) of team leaders agreed or strongly agreed that *'Having a monthly check-in call with a Pathways staff member helped our team stay on track,* and 83% agreed or strongly agreed that *'Submitting monthly strategy maps helped our team meet our stated goals.'*

Response to three other survey items asked of both leaders and members were not as unanimous. Percentage agreed or disagreed for leaders and members are in parentheses.

- *Our team made progress at a faster pace than other university groups I'm a part of* (83% for leaders; 29% members).
- *The number of people on campus involved with our efforts has grown* (83% leaders; 57% members).
- *My team focused on specific or concrete goals (outcomes) in our meetings* (33% leaders; 71% members).

Overall, results indicate that leaders perceive the benefits of strategic doing to a greater extent than members. It is unclear why this difference exists. Differences could be due to the fact that leaders are more actively involved in strategic doing as a result of regularly scheduled check-in calls. The lukewarm response from members suggests that team leaders may require additional training on how to engage members in the process. Likewise, members may be reluctant to attribute team successes to strategic doing, because of their reduced engagement.

In addition to collecting the quantitative data above, focus groups provided leaders an opportunity to provide qualitative feedback about their experience with strategic doing. Overall, interviewees were satisfied with the strategic doing process. The process empowered leaders to plan efficiently and execute effectively, and if it were not for the accountability associated with strategic doing, institutions may not have progressed as much as they did. The responses also suggested some ways in which the approach could be improved or refined. Specific responses provided included the following (all from team leaders):

"When you're trying to do something innovative, using this approach is helpful. […] I think this process was essential."

"I needed the fear of looking like a goof. It's a good accountability tool."

"It gave us an organizing framework to prioritize and coming up with a plan. We had a short amount of time to come up with our objectives and what we're going to do – it organized that process for us."

"The check-in calls were nice – because having a deadline forced me to get something done […]. I thought there it might have been nice to have had someone who had the same objective or have someone who had already accomplished something – or even a strategic doing map from someone who had the same objectives."

"Because we were always working towards our goal, we never really got to measuring how well we had done."

Strategic doing in other engineering education settings

This paper has described the use of strategic doing in the Pathways project specifically. Since the start of that project, there have been several other initiatives that have adopted the approach for their work:

- Several Pathways team members have introduced the approach to other change efforts at their university, beyond innovation and entrepreneurship topics (and in some cases, beyond engineering).
- At Purdue University, the School of Engineering received a grant from the National Science Foundation to overhaul its mechanical engineering department. The developer of strategic doing is a co-PI on that project and is guiding the leadership team using the approach. In addition, the dissemination and sustainability plan for the project envisions nurturing a national network of institutions using strategic doing to improve their engineering programs.
- Also at Purdue University, a faculty member is experimenting with teaching strategic doing to students as a way to work in a collaborative group. The initial effort was received positively and the faculty member has been approached about scaling the instruction so that all incoming freshman are trained in strategic doing.
- Purdue's Discovery Park and Indiana University are using the process to assemble multi-disciplinary research teams to develop proposals for "grand challenges" in food, energy, water and health care.

Ongoing adaptation and future research

In both the second and third cohort, the materials and activities used with the Pathways schools have been modified based on evaluation feedback. The data presented here suggest many additional avenues for future activities, including:

- Does the introduction of new interventions (or completion of previously-started interventions) continue beyond the first six months? Does the pace or trajectory of that work differ, and if so, how?
- Are there team leader attitudes or behaviors that lead to greater success, and if so, how can those behaviors be fostered?
- Do a team's challenges to implementation change over time, and how can strategic doing be adapted to meet those challenges?
- How can a stronger impact evaluation component for the team's individually efforts be embedded in the approach?
- How might the approach be effectively taught in a "lower-touch" model – that is, without multiple in-person facilitated workshops?

References

1. Cockburn, A. (2006). Agile software development: the cooperative game. Pearson Education.
2. Nilsen, E., & Matthew, V., Shartrand, A., & Monroe-White, T. (2015). Stimulating and Supporting Change in Entrepreneurship Education: Lessons from Institutions on the Front Lines Paper presented at 2015 ASEE Annual Conference and Exposition, Seattle, Washington. 10.18260/p.24738

3. U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics, Integrated Postsecondary Education Data System (2014). Fall 2014 Undergraduate Engineering Student Enrollment.

4. Nilsen, E. A., Matthew, V., Besterfield-Sacre, M., & Monroe-White, T. (2015). Landscape analysis as a tool in the curricular change process. In Frontiers in Education Conference (FIE), 2015. 32614 2015. IEEE (pp. 1-7). IEEE

5. Wenger, E. (2000). Communities of Practice: Learning, Meaning, and Identity, 1st ed. New York: Cambridge University Press.

6. Chandler, A. D. (1990). Strategy and Structure: Chapters in the History of the Industrial Enterprise. Cambridge, Mass.: M.I.T. Press.

7. Morrison, E. (2013). "Strategic Doing": A New Discipline for Developing and Implementing Strategy within Loose Regional Networks. Paper presented at Australia-New Zealand Regional Science Association International Annual Conference, 2013.

8. Cooperrider, D. & Whitney, D. (2005). Appreciative inquiry: A positive revolution in change. Berrett-Koehler Publishers.

9. Morrison, E. (2012). Network–based Engagement for Universities: Leveraging the Power of Open Networks. Prepared for the 10th PASCAL International Observatory Conference: The Role of Higher Education in Local and Regional Social and Economic Development, 2012.

10. Eisenhardt, K., & Sull, D. (2001) Strategy as Simple Rules. Harvard Business Review, 79 (1), p. 106-116.

11. Dancy, M., & Henderson, C. (2008). Barriers and promises in STEM reform. Presented at National Academies of Science Promising Practices Workshop, Washington DC, 2008.

12. Byers, T., Seelig, T., Sheppard, S., and Weilerstein, P. (2013). "Entrepreneurship: Its Role in Engineering Education," Bridge Link. Eng. Soc., vol. 43, no. 2, pp. 35–40.

13. Giersch, S., & McMartin, F. P., & Nilsen, E., & Sheppard, S., & Weilerstein, P. (2014). Supporting Change in Entrepreneurship Education: Creating a Faculty Development Program Grounded in Results from a Literature Review. Paper presented at 2014 ASEE Annual Conference, Indianapolis, Indiana. https://peer.asee.org/23077