A MODEL FOR TRANSFORMING ENGINEERING EDUCATION THROUGH GROUP LEARNING

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ABSTRACT
Engineering educators at Dublin Institute of Technology (DIT) have successfully implemented pedagogical change. They now use group-based, student-centred, inquiry-driven approaches in each year of their electrical engineering programmes. Their objective is to foster students' professional *and* personal skills (e.g., teamwork, communication, creativity, critical thinking, ethics, self-directed learning). This paper explores how change was achieved. It provides graphic models that extend the authors' prior research by incorporating the standard adoption of innovation curve. Results indicate that top-down capacity-building programmes and policies stimulated bottom-up change—transformative change initiated by a group of individuals working closely with a champion and a sage advisor. Leaders at DIT are beginning to promote wider and deeper transformation by introducing the change model into new contexts.

Keywords: Learning groups, organizational change, change theory, change models

1 INTRODUCTION

Ireland's Dublin Institute of Technology (DIT) is succeeding in transforming engineering education to become more hands-on and student-centred. Much of its success is due to the efforts of individual teachers and students who are actively engaged in learning groups. Over the past five years at DIT, learning groups have enabled the engineering faculty to transform their electrical engineering programme away from using traditional pedagogies (that relied on lectures and rote-experiment laboratory work) toward an increasingly entrepreneurial culture that models the behaviours of some of the world's greatest engineers, such as James Dyson, Sir Jonathan Ive, and Gert Hildebrand.

Today, learning across DIT's electrical engineering programmes is group-based, student-centred and inquiry-driven. Much of the success of the curricula accrues from: (1) placing issues related to learning at the forefront of daily conversation and (2) using peer-learning groups—of faculty as well as students—to investigate issues and pose viable options. Creative solutions can then emerge in relation to engineering / design and education.

To understand what happened in this programme—and describe the change process and why it happened—we conducted qualitative research to explore the phenomenon of being part of a faculty-learning group that focused on implementing change. We sought to understand the experiences of teachers who had caused change to happen in their labs and classrooms. Seeking to understand the group-learning phenomenon, we conducted semi-structured interviews with the seven faculty members who have been most active in the change process. Participants in the study represented 27% of the total body of faculty in the program. A detailed description of the study is being published elsewhere; this particular paper summarizes major points and extends ideas presented in that paper [1]. In the initial paper, we sought to identify crucial factors in the programme's shift to group-based, inquiry-driven learning. This paper provides new graphic models to help others who want to implement similar changes in their own programmes. In doing so, we interpret findings in relation to Rogers' adoption of innovation model [2] and recent interpretations of the model by Lowe [3].

2 NEED FOR CHANGE

The need to transform engineering education is well documented. In the United States, the National Science Board [4] insisted engineers "need to be adaptive leaders, grounded in a broad understanding

of the practice and concepts of engineering." In most universities, engineering educators have been slow to address this mandate [5]. The NSB cited a troubling deficit in engineering education, asserting that engineering graduates are often unable to navigate complex interrelationships particularly when they involve an array of environmental and human considerations. The NSB has been quite specific in how it would like change to occur. As a means for improving engineering education, the NSB advocates using an assortment of experiential learning practices inherent to problem-based learning—including hands-on activities, collaborative work, real-life applications that have commercial and social relevance, and the integration of content at the systems and component levels in STEM (science, technology, engineering, mathematics) subjects. Such practices are particularly important in programmes that seek to develop students' design-thinking skills. We argue that effective education requires sustained delivery of student-centred practices such as these throughout the curriculum—and that this requires many teaching staff to innovate their ways of thinking and of behaving in the classroom. Teachers must shift focus from how they *teach* to how students *learn*. They need to assess learning outcomes.

3 EFFICACY OF LEARNING GROUPS

The engineers we are educating today must be able to recognize, define, and address issues that are so large and complex that they have not yet been named. This is why people working at the forefront of innovation are embracing group learning and trans-disciplinary collaboration as mechanisms for fostering change. They see that teams are more effective than individuals in grappling with slippery issues and ill-defined problems. The economic benefits can be massive through reductions in cost and time overruns. As such, faculty-learning groups are popping up on many campuses. At Emory University [6] and Northern Arizona University [7], peer-learning groups composed of faculty, staff, and students have helped address issues of environmental sustainability. At DIT, such groups have been used to build capacity, hone techniques, and empower individuals to implement change in the way engineering is both taught and learned [1].

Those who practice learning in groups generally reflect a constructivist view of knowledge. The basic premise is that, working together, people construct the world around them. Their reality, and perhaps even all "reality" is a social construct. It reflects what they, as a group, collectively choose to see, recognize, name, explore, understand, and/or build. Today, more and more educators recognize the value of having students work together—to learn more than just how to solve pre-determined problems or achieve a clear-cut, verifiably true answers that can be found in books. By-products from teamwork can be as valuable as the actual products a student team produces. Nonetheless, the complex designs student teams produce today are often impressive. Project-Based Learning (PBL) provides a challenging outlet for teams to think creatively and also develop skills related to management, leadership, consensus building, evaluation and synthesis, and design- and decision-making.

4 BRIEF DESCRIPTION OF STUDY

To investigate such issues, we are in the process of conducting a four-part study. First, to develop initial understanding, the primary author reviewed existing documents [8] [9]. In this phase, she interviewed eight people from various parts of the institute to ascertain what types of changes had occurred with regard to learning and teaching at DIT. Second, we conducted a phenomenological study wherein we interviewed seven of the nine participants in the electrical engineering faculty-learning group (held in 2009-2010) that implemented changes to the program. Four of these individuals participated in both the first and second parts of the study. We used member checking to validate our interpretation of the interview data. The third part, currently underway, involves interviewing students about their experiences working in groups. The fourth part will involve an online survey to query staff across the entire institute. The intention of the survey is to provide a broader understanding and help us assess additional places in DIT where such changes have occurred.

5 SYNOPSIS OF FINDINGS

A number of themes emerged in the first phase—during analysis of the interviews about faculty experiences learning in a group. These included: key players, benefits of being involved, specific topics the group discussed and learned, frustrations people encountered, and identification of who got involved. Other determining factors that emerged related to: professional development / capacity

building programs provided by DIT's Learning, Teaching and Technology Centre (LTTC), shared culture and "group think," communicating values, and barriers in the system. Overall, four distinct roles emerged that appeared crucial to this group's success and seem applicable to other, similar situations. These roles included the: *champion* who provided focus and belief, *sage advisor* who cited research and theory and described relevant examples that had occurred at this institution in the past, *institute* and its programmes and policies, and—most importantly—*individuals working together in groups* seeking to learn and to change [1].

6 RELATION TO ADOPTION CURVE

The situation at DIT replicates Greg Lowe's description of socially driven change [3]. Lowe explains that typically, in enterprises where change is driven by social factors, "parts of the organization are already changing prior to full articulation of a problem or solution." This holds true at DIT. "Once a company finds itself in the midst of groundswell of social adoption," Lowe offers as advice, "it needs to determine how to effectively integrate it into its culture and operations." He recommends the organization determine whether the change is occurring widely or is limited to one department. That way, leaders can assess the change in relation to the theories about how products and technologies get adopted into common use [10] and to Rogers' adoption of innovation model [2].

6.1 Increasing "Market Share" among Educators

According to Rogers' model, the distribution of individuals adopting new products and techniques follows a standard bell curve. Innovators and Early Adopters represent 16% of any given population. They counter-balance another 16% of the population that lags behind with regard to change. The bulk of people, a full 68%, fall in the middle. Roughly half of these people (known as the Early Majority) implement change sooner than others (the Late Majority). In Figure 1, Havassing [11] has illustrated the growth of market share growth (or adoption) over time using a light-coloured line. With regard to this model, Laggards become drawn in because the innovation eventually saturates the market and drives other choices into extinction.

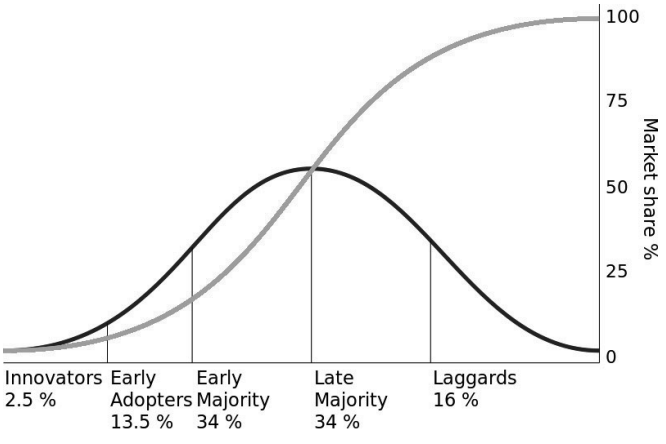

Figure 1. Rogers' Adoption of Innovation Model (source: Hvassing, 2012)

In higher education, the adoption of new teaching techniques takes a very long time, given that university teachers have control over how they teach. In such settings, Laggards can easily continue using the methods they know best and ignore more effective approaches. This particular market (academia) can't force individuals to change using the mechanisms that corporate leaders can. There is little means for influencing how individuals with job stability and/or tenure teach. Nevertheless, at the start of a change initiative, academic leaders can—and probably should—work to identify and relocate Laggards. They can create other opportunities for laggards to work on topics where they will not adversely affect progress in the desired area. This has been described as a "garbage can model of organizational choice" [12].

Lowe's central claim is that if leaders focus on engaging the leading 60-70% of teachers (those on the left side of the bell curve), some of the Bystanders and Laggards will come along in their own good

time, without dedicated allocation of precious resources. This is happening successfully at DIT. Investment in Innovators and Early Adopters takes the form of fellowships, grants, and awards. For instance, annual teaching fellowships are allotted to individuals who align with the overarching vision of hands-on, student-centred teaching. The champion of pedagogical change in electrical engineering was, in fact, supported by a fellowship in 2009-10, when he organized the learning group we studied.
In places like DIT, Emory University, and Northern Arizona University, *individual faculty members* have leveraged their innovations and achieved buy-in from others *through the use of peer learning groups*. At DIT, Early Adopters (i.e., the champion and sage) encouraged others to join in the change. They successfully gathered an Early Majority and achieved a tipping point whereby those who tend toward the late majority are becoming engaged in the topic of central concern to them (implementing group PBL in electrical engineering). As illustrated later, peer pressure combined with a sense of improved student outcomes and student engagement resulting from innovative pedagogies, as well as increased demand from students, have encouraged more and more faculty to change their ways.

6.2 Enhancing "Return on Investment"

Lowe suggests means to balance benefit and cost in relation to Rogers' model. He looks specifically at investment and return—describing those who are slow to adopt new innovations as Sceptics, Bystanders, and Naysayers (see Figure 2). The highest return on investment, he argues, comes from (1) convincing the Early Majority and (2) converting Sceptics. Since Sceptics represent a bulk of those in the centre—including the Early Majority and Late Majority—it makes good sense to work to get them on board with a desired change. This requires substantial investment of resources and thus necessitates careful consideration. Lowe says that even successful change initiatives achieve only 60-70% buy-in and worrying about the Late Majority and Laggards is usually counter-productive.

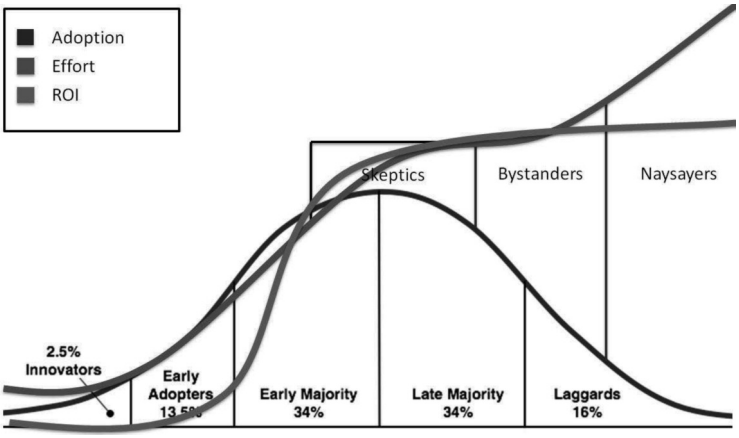

Figure 2. Lowe's Return on Investment Curve (source: Lowe, 2012)

Lowe believes that getting people involved at the leading edge requires: configuring programs, making resources available, defining best practices within the community, sharing techniques and success stories publically and through word-of-mouth. Getting the trailing edge moving carries much greater cost. Convincing these people typically will require expenditures for: printed materials, workshops and seminars, town hall meetings, travel for exposure and professional development and coaching / mentoring / remediation programmes. The time, effort, and money expended to convert Bystanders and Naysayers will far outweigh the benefit in most cases, Lowe argues.
Many academics simply will not change how they teach. It is more important to help those who are implementing the change—and enable them to do so fully and leverage their work as much as possible. Lowe notes that sometimes leaders need to help the teams they supervise enjoy and celebrate success, as well as envision failure. He argues that people typically do not have a clear picture of how to proceed and that they need this. At DIT, the faculty learning-group constructed much of the vision and picture of success. They drew from their LTTC coursework and conversations with peers.
Nevertheless, at DIT, the champion of the electrical engineering effort did wish for more support and clearer vision from the top. He expressed exactly what Lowe described. Without targeted assistance,

people on the leading edge achieve just 10-15% of their capacity Lowe asserts. Finding ways to build their skills—perhaps using wikis and blogs to promote sharing—can help people make their change initiative successful. DIT is building capacity through its (required) degree programmes and frequent (but typically optional) staff education seminars.

The faculty-learning group under investigation represented a new and different way to build skills in a lively, fun, face-to-face forum [1]. It focused on building *one* specific capability—facilitating group work among students—just as Lowe recommends. The effort was successful in gathering enough participants to implement and then institutionalize innovative approaches. The larger college is now working to grow innovation by promoting the use of learning groups and other successful techniques among more and more schools and programmes.

Since 2006, there also has been a concerted effort at DIT to bring new people on board who can support this sort of pedagogical change. In 2006, DIT implemented a new policy that required each newly hired faculty member to complete a post-graduate diploma in Learning and Teaching, a programme run through the LTTC. The policy is consistent with Lowe's approach. He identified recruiting new hires into the change initiative as a good use of resources, and one that is likely to have positive return on investment. He cautions that these programs can become stale, and he recommends keeping these programs responsive and user-friendly, saying that by continually sharing "the success that your adopters are realizing inside the organization, you will eventually draw the others in." Figure 3 illustrates how various factors evident at DIT fit in relation to Rogers' standard adoption curve.

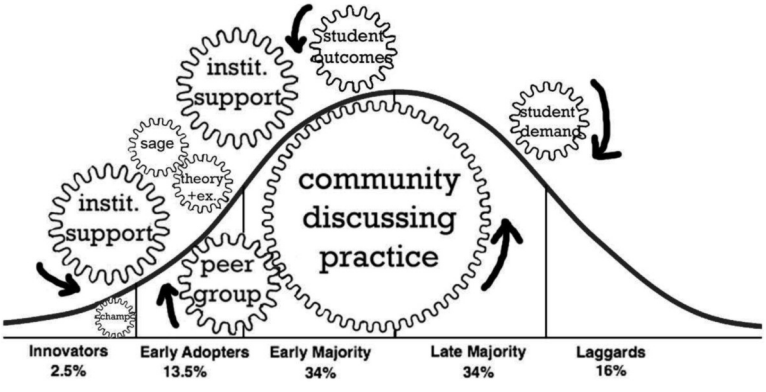

Figure 3. Factors Driving the Adoption Curve at DIT (Source: Authors)

In this scheme, the champion is the primary Innovator. As one of 22 teachers on his programme, he equates to 4.5% of the overall pool. Other core members of the faculty-learning group (n=3, or 13.6%) constitute the Early Adopters. They have helped increase the engagement of people who already tended to use Problem-Based approaches to teaching and the larger community. They accomplished some of this through their active engagement in Programme Meetings. They also won converts to the community by continually chatting about pedagogy with their colleagues over coffee / tea and lunch (as per Irish custom). Because they have been able to maintain discussion of teaching in these conversations, they have been able to amass a growing community of teachers who discuss practice and find ways to bring effective new approaches into more and more labs and classrooms.

This effort seems to have been appealing to the Early Majority because they can see improvements with regard to student learning outcomes. Today, even the Late Majority is joining the electrical engineering innovation crusade; more and more teachers sense pressure (from students and faculty) to make their classes more interactive. The individuals at the leading edge of this campaign have seen benefits from having access to LTTC programs, fellowships, and resources. They also benefitted from direct assistance from the sage advisor who brought theory and examples to life for them.

In this way, the scenario at DIT contrasts with Lowe's model. In the DIT case, formal programs were instrumental at the leading edge. Lowe says that investments made on those at the leading edge have relatively low return on investment. In other words, the individuals on the leading edge would be good teachers even without the resources. What this view fails to recognize, however, is the influence these specific individuals can have on the rest of the social context. At DIT, those at the leading edge have been powerful drivers of change. They felt empowered and they leveraged resources to great effect.

7 SUMMARY

Lowe cautions that changing behaviour "always takes a long time; it is always best to be patient and focus on activities where you can have greater impact." In fact, a primary difference between business and higher education sectors involves the rate of change [13]. Universities have very few mechanisms for requiring changes in teaching practice. In contrast, the corporate world has the capacity to demand change among employees. Yet teachers at DIT have been able to achieve (and grow) behaviour change. The difference between this and other situations seems to be the delicate balance of top-down and bottom-up support present in the system. In this case, change appears to be occurring as a result of programmes established by someone at the "top" a decade ago; today the source of centralized "ownership" is no longer clear. As a result, from the vantage point of today's stakeholders, pressure to change seems to be coming from the bottom up and also supported from the top down. This seems to have enhanced the receptivity of individual teachers to implement change [3] [14].

In fact, the success of bottom-up programmes appears to have been a primary driver in adoption of the institute-wide policy requiring new faculty members to earn qualifications in teaching. Members of the LTTC (rather than central administration) proposed the policy, but formalizing it also required support from DIT teacher's union. In this case, return on investment is likely to grow as more and more teachers complete professional-development programmes offered by the LTTC… and as teachers continually engage each other in critical dialogue and Irish-style academic chat. Leaders at DIT can enhance this change movement by monitoring successes, supporting champions, applying steady support as well as making strategic investments at crucial times. Although they cannot demand the type of change that engineering and science organizations seek, they certainly can—and have—set the context for positive growth and development, and for truly transformative change.

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