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Shannon Chance

*Technological University Dublin*, [shannon.chance@tudublin.ie](mailto:shannon.chance@tudublin.ie)

Gavin Duffy

*Technological University Dublin*, [gavin.duffy@tudublin.ie](mailto:gavin.duffy@tudublin.ie)

Brian Bowe


*Technological University Dublin*, [Brian.Bowe@TUDublin.ie](mailto:Brian.Bowe@TUDublin.ie)

Mike Murphy

*Technological University Dublin*, [mike.murphy@tudublin.ie](mailto:mike.murphy@tudublin.ie)

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Tony Duggan

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# A MODEL FOR TRANSFORMING ENGINEERING EDUCATION THROUGH GROUP LEARNING

Shannon CHANCE<sup>1</sup>, Gavin DUFFY<sup>2</sup>, Brian BOWE<sup>2</sup>, Mike MURPHY<sup>2</sup> and Tony DUGGAN<sup>3</sup>

<sup>1</sup>Hampton University

<sup>2</sup>Dublin Institute of Technology

<sup>3</sup>Hauste Group

## ABSTRACT (250 WORDS MAX)

Electrical engineering educators at Dublin Institute of Technology (DIT) have successfully implemented pedagogical change. They now use group-based, student-centered and inquiry-driven approaches to teach emerging engineers. The objective of this was to foster students' personal as well as professional skills (i.e., teamwork, communication, self-directed learning, etc.). This paper explores how such change was achieved and provides graphic models that draw from prior phenomenological studies and incorporates aspects of Rogers' (1962) product adoption curve and Lowe's (2012) interpretations of it.

*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 be more hands-on and student-centered. Much of its success is due to the efforts of individual teachers and students who are actively engaged in learning groups (Chance, Duffy, Bowe, under review). These learning groups have enabled, over the past five years the engineering faculty at DIT to transform the electrical engineering program away from traditional pedagogies that relied on lectures and rote-experiment laboratory work and into an almost entrepreneurial culture modeling the behaviours of some of the worlds greatest engineers such as James Dyson, Sir Jonathan Ive, and Gert Hildebrand.

Today, learning across the program is group-based, student-centered and inquiry-driven. Much of the success of this program accrues from: (1) placing issues related to learning at the forefront of informal, 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 both engineering/design and education.

In order to understand what happened in this program and describe the change process and why it happened, we conducted a qualitative study that used interpretative methods to explore issues. We sought to understand the experiences of teachers who had caused change to happen in the classroom. In order to understand that phenomenon, we conducted semi-structured interviews with the seven faculty members 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 (Chance, Duffy, & Bowe, under review). This particular paper summarizes major points and extends the ideas presented in that paper. In the initial paper, we sought to identify crucial factors in the program'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 programs. In this paper, we also interpret our findings in relation to the product adoption model (Rogers, 1962) and interpretations of this model by Lowe (2012).

## 2 NEED TO CHANGE

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

understanding of the practice and concepts of engineering” (2007, p. 2). In most universities, engineering educators have been slow to address this mandate (McKenna et al., 2011). 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) courses. Such practices are particularly important in programs that seek to develop students’ design-thinking skills. We argue that design education requires the use of such practices through sustained delivery throughout the curriculum, which requires many teaching staff to innovate their ways of thinking and of behaving in the classroom (so that they shift from think of how they teach to focusing on what students are learning).

### **3 LEARNING GROUPS**

The practice of group learning takes a constructivist approach to knowledge; a basic premise is that, together, people construct the world around them. The reality is in fact what they, as a group of people, collectively choose to see, recognize, name, explore, build and test solutions. Today, more and more educators are seeing the value of having students work together to learn more than just how to solve a pre-determined problem and achieve a clear-cut, verifiably true answer. Other byproducts from team working can now often be as valuable as the work on a core problem or challenge providing an outlet for creativity for teams to build, make concessions through the design process and not waste time during the design process by creating a framework for everyone’s contribution to be captured.

The engineers we are educating today must be able to recognize, define, and address issues that are so large and complex that they have yet to be named. This is why people working at the forefront of innovation are embracing group learning and trans-disciplinary collaboration as mechanisms for enhancing their capacity to foster change. They see that teams are more effective than individuals in grappling with slippery issues and ill-defined problems and the economic case can be massive through reductions in cost and time overruns. As such, faculty-learning groups are popping up on many campuses. At Northern Arizona University and Emory University, for instance, peer-learning groups composed of faculty, staff, and students have helped address issues of environmental sustainability (Bartlett, 2005; Chase & Rowland, 2005). 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.

### **4 BRIEF DESCRIPTION OF STUDY**

To investigate this issue, we conducted a three-part study. First, to develop initial understanding, the primary author reviewed existing documents (Fitzpatrick & Harvey, 2011; Learning, Teaching, and Technology Centre, 2010). In this particular phase we 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 (conducted during the 2009-2010 school year) 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 of our study, currently underway, involves conducting an online survey to query staff across the entire institute. This will provide a broader perspective and help us assess where else such changes have occurred at DIT.

### **5 SYNOPSIS OF FINDINGS**

A number of themes emerged in analysis of the phenomenological interview data. These include the importance of having a champion and a sage advisor, the topic of individuals working together, the benefits of being involved, what topics the group discussed and learned, frustrations they encountered,

and identification of who got involved. Other key 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. Key players included: the *champion* who provided focus and belief, the *sage advisor* who cited research and theory and described relevant examples that had occurred at this institution in the past, the *institute* and its (LTTC) programs and policies, and—most importantly—*individuals working together in groups* seeking to learn and to change. For more on these findings refer to Chance, Duffy, and Bowe (under review).

## 6 RELATION TO ADOPTION CURVE

The situation at DIT followed Greg Lowe’s description of socially driven change. Lowe explains that 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” (§ 1). He adds, “Once a company finds itself in the midst of groundswell of social adoption, it needs to determine how to effectively integrate it into its culture and operations” (§ 2). Lowe recommends the organization determine if 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 (Beal, Everett, & Bohlen, 1957) and the standard adoption model, which uses a standard bell curve (Rogers, 1962, 1983). According to Rogers’ model, the distribution of individuals’ inclination to adopt new products and techniques follows this standard curve (the dark line in Figure 1)

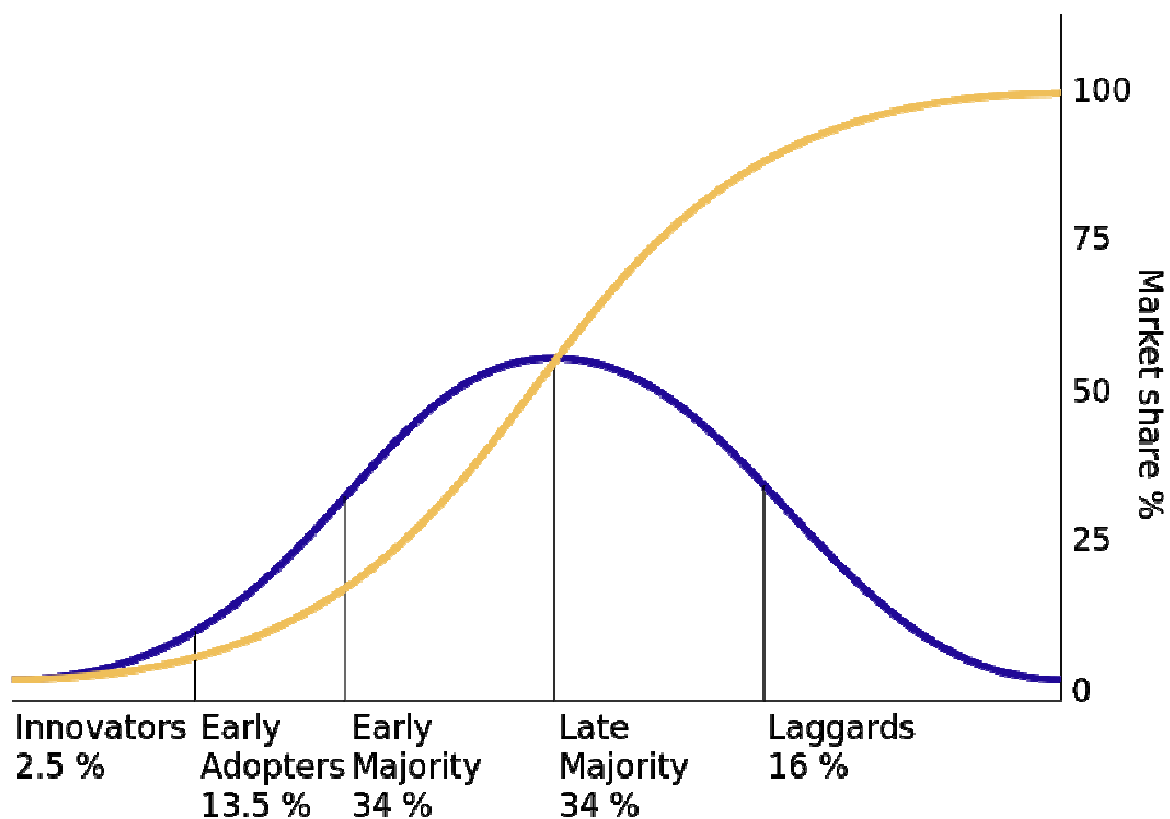


Figure 1 Rogers’ Innovation Diffusion Model

According to Rogers (1962), 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. Some of these people (known as the “early majority”) will implement change sooner than others (i.e., the late majority). In Figure 1, the growth of market share, i.e., adoption, over time is illustrated with a light line. In product diffusion, laggards eventually become drawn in because the new product simply saturates the market and drives other choices into extinction.

In university settings the adoption of new teaching techniques takes a very long time. Given that the laggards to change have control over how they teach; they continue using the methods they know best. The ‘market’, i.e., the university, can’t force change as it can in the business arena because professors often have tenure and there is little means for influencing how they teach.

At DIT, Emory University (Bartlett, 2005) and Northern Arizona University (Chase & Rowland, 2005), individual faculty members were able to leverage their innovations and achieve buy-in. Early adopters (i.e., the champion and sage) encouraged others to join in the effort to 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 (i.e., implementing group-based Problem-Based Learning in the electrical engineering program).

Greg Lowe (2012) seeks to balance benefit and cost considerations in relation to Rogers’ product adoption curve. Lowe looks specifically at investment and return and he posits that those who are slow to adopt new innovations represent skeptics, bystanders, and naysayers (see Figure 2). Since skeptics represent a bulk of those in the center—including the early majority and late majority—it makes good sense to try to get them on board with the change. This requires substantial investment of resources and thus requires careful consideration. Even successful change initiatives achieve only 60-70% buy-in says Lowe, so worrying about the late majority and the laggards is counterproductive (unless, of course, key players with regard to the desired change are in the late majority or laggard groups). Lowe asserts that the highest return on investment comes from (1) convincing the early majority and (2) converting skeptics.

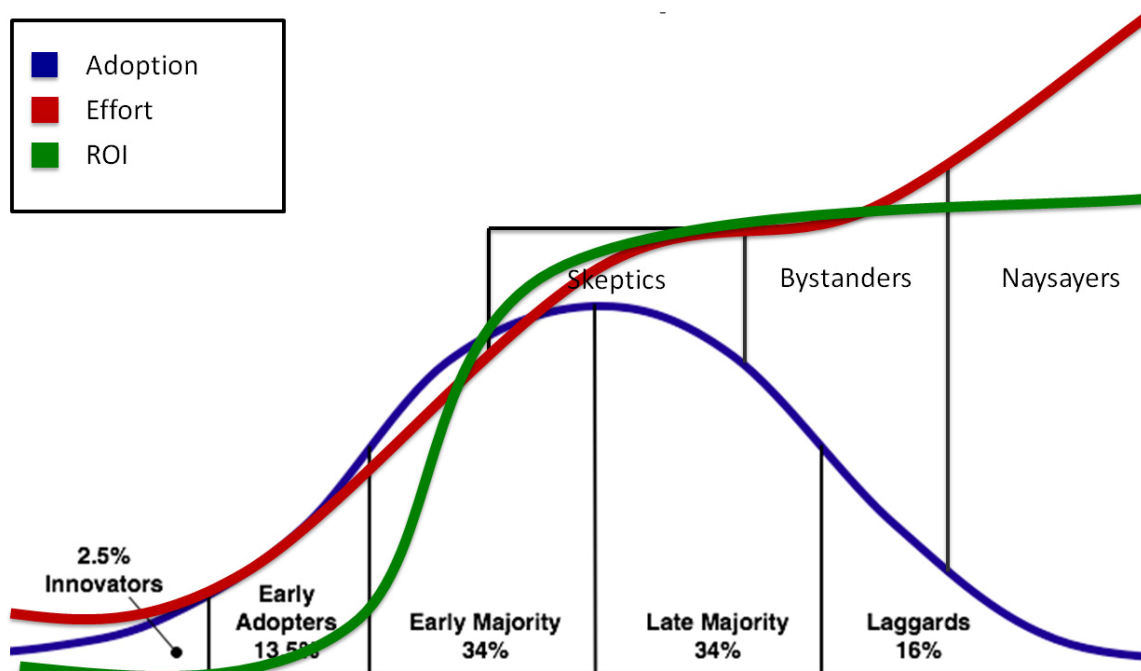


Figure 2 Lowe’s Return on Investment Curve

Self directed work teams can sometimes mean helping that team to envision failure and the comparative feelings of success. The classic point of resistance is “what does this mean to me?” the start point of such a programme can often be psychometric profiling and indeed moving quickly to identify and relocate laggards (creating other opportunities for them to work in ways that will not adversely affect progress).

To get 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 (Lowe, 2012). To get the trailing edge moving requires much greater expense, according to Lowe. Convincing these people will likely require printed materials, workshops and seminars, town hall meetings, travel for exposure and professional development and coaching/mentoring/remediation programs. The cost (in time, effort, and money) expended to convert

bystanders and naysayers far outweighs the benefit in most cases. Many of them simply will not change how they teach.

Lowe's central claim is that if academic 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, where annual teaching fellowships are allotted to individuals aligned with the shared vision of hands-on student-centered teaching. The champion of the change movement in electrical engineering was, in fact, supported by a teaching fellowship in the year he organized the peer-learning group we analyzed.

It is important to help those who are implementing the change to enable them to do so fully and to leverage their work as much as possible. Lowe argues that usually these people do not have a clear picture of how to proceed. Indeed, the champion of the electrical engineering effort at DIT stated a wish for more support and a clearer vision from the top. He was expressing exactly what Lowe describes. Without targeted assistance, he says, people on the leading edge often achieve just 10-15% of their capacity. So finding ways to build their capacity, such as sharing effective approaches via a "capability blog," helps distinguish successful change initiatives from those that fail.

DIT is addressing this particular issue (capability) through structured face-to-face meetings rather than blogs. The faculty-learning group assembled in electrical engineering focused on one capability—facilitating group work among students—just as Lowe recommends. The success of this effort is in gathering enough participants to effectively implement and then institutionalize noteworthy innovations. The College is now working to grow the group of innovators by promoting successful techniques and processes among a wider audience (i.e., additional schools and programs). There has been a concerted effort at DIT since 2006 to bring new people on board with the pedagogical change initiative. In 2006, DIT implemented a new policy that required each newly hired faculty member to complete a post-graduate diploma in Learning and Teaching, run through the LTTC. This policy is highly consistent with Lowe's approach. He described 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. "By continuing to share the success that your adopters are realizing inside the organization, you will eventually draw the others in," says Lowe.

Figure 3 illustrates how various factors evident at DIT fit in relation to Rogers' standard adoption curve. In this scheme, the champion represents the innovators. He is one of 22 teachers on his program. Other teachers who joined the peer-learning group constitute the early adopters. Because this group continually chats informally over coffee, tea and lunch with many other faculty members (as per Irish custom), and because it has maintained a focus on teaching issues in these conversations, it has been able to accrue a community of teachers who currently discuss practice and find ways to bring effective new approaches into more and more classrooms. This effort is all the more 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 saw 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 return on investment is low at the leading edge. In other words, the individuals on the leading edge would be good teachers even without the resources. What this leaves implicit, however, is the reach these specific individuals can have on the rest of the system (in a socially driven context). At DIT, they were directly empowered by the resources allotted to them and they leveraged these resources to great effect.





Figure 3 Linking DIT's initiatives to Adoption Curve

Lowe advises, "Behavior change always takes a long time; it is always best to be patient and focus on activities where you can have greater impact." At DIT, return on investment is likely to grow as more and more teachers complete the capacity-building professional-development programs offered by the LTTC and as they and others continually engage with colleagues in critical dialogue and Irish-style academic chat. Leaders can enhance this change movement by monitoring successes, supporting champions, and applying resources in strategic areas and at crucial times. Although they cannot directly implement the type of change NSB requires, they certainly can—and have—set the context for positive growth and development, and for truly transformative change.

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