CHAPTER THREE

Diffusion Theory and Actor-Network Theory: Two Views on an Innovation

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Abstract

For more than two decades there has been a continuing and significant financial outlay in Australia to equip schools with computers and related communication technologies. The adoption and adaptation of these technologies in schools has been the focus of much research. Where research has been concerned with accounting for the success or failure of such innovations, recourse, either explicitly or implicitly, to tenets of diffusion theory has been common. This paper reports on a study of the development and implementation of an Education Queensland initiative, the ConnectEd project. The study, informed by actor-network theory, analyses key concepts in the overall process of innovating and details the ways in which diffusion theory limits understandings of innovation in education.

Introduction

The presence of computers and associated technologies in schools is now commonplace. Indeed for more than twenty years schools have responded to the development of new computerised

technologies. Significant financial outlay has been evident by state education departments and independent schools. To be sure, there has been a massive outlay of funds to equip schools with computers and more recently information and communication technologies (ICT's) to the point that now they are a routine part of daily school life.

Although the physical presence of these technologies is evident, not as clear is the extent to which teachers make use of these technologies. Much research has been undertaken distinguishing a variety of facets of computer use. Whilst too numerous to list here, this research ranges from areas such as technology and literacy to social justice issues and pedagogical considerations of using technologies. However, for the most part, implicit in these discourses is that teachers do use these technologies (although not always happily). There appears to be little research on the events and strategies used by state education departments or administrators in independent schools to ensure that teachers use these technologies in the manner intended. The question stemming from this observation addresses issues of how and why it is that teachers integrate these technologies into their educational programs. As Hodas (1996) argues, in response to the introduction of technologies, the capacity of schools to adapt these technologies to the routines and practices that have always been carried out in the classrooms is clearly evident. Certainly, there are many teachers who simply continue teaching as they have always done (Lankshear & Bigum 1999). This paper examines the ways in which a state education department, Education Queensland, attempts to ensure that teachers integrate information and communication technologies in their education programs.

The introduction of these technologies is a clear example of implementing an innovation, the focus of the current

paper. The literature on educational innovations paints a poor picture for the chances of effective implementation (Hargreaves, Lieberman, Fullan & Hopkins, 1998). This paper contrasts two sets of ideas concerning innovations – Rogers' (1995) theory of diffusion of innovations and an actor-network theory perspective. Similar contrasts between actor-network theory and the diffusion theory have been carried out by McMaster, Vidgen & Wastell (1997), and by Tatnall (2000). McMaster el al (1997) examined the failure of a UK City Council to adopt a structured method for systems development; and Tatnall (2000), examined a curriculum innovation within a university faculty.

Before applying both these approaches to examine the development of a specific innovation, the integration of ICT's into the curriculum by teachers in the geographically large state of Queensland, I will briefly introduce the two ways of thinking about innovations. This paper concludes with a discussion of the significance of comparing these two ways of conceptualising innovation, and outlines reasons why actor-network theory is a more helpful framework for the discussion and understanding of technological innovation.

Diffusion Theory

Rogers' theory of diffusion, beginning with his first publication of *Diffusion of Innovations* in 1962, is and continues to be widely used as one way of thinking about the way in which innovations are introduced and adopted. He defines diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system. Stemming from this framework for studying innovations, then, are the key concepts of innovation, communication channels, time and social systems.

Innovation refers to an idea, practice or object, which is perceived by an individual as new. It must be new to the individual, called the *adopter*, although the innovation may not be new *per se*. The rate at which an innovation spreads through a group of potential adopters is influenced firstly by characteristics of the innovation itself. These include: relative advantage – the degree to which it appears superior to an existing product or practice; compatibility – the degree to which it matches values and experiences of individuals in the community; complexity –the degree to which it is relatively difficult to understand or use; trialability – the degree to which an innovation may be experimented with on a limited basis; and observability – the degree to which the results of an innovation are visible to others. Secondly, the rate of adoption may be influenced by characteristics of the adopter. These include level of education, social status and 'cosmopolitanism'. Finally, organizational issues such as organizational structure, size, and degree of decentralization or centralization may also influence the rate of diffusion.

The diffusion theory has many 'categories' for individuals. One such group is that of opinion leaders, these individuals influence adopters of innovations either positively or negatively. They are also influential depending of the level of technical competence, social accessibility, level of conformity to social norms and their degree of support for the innovation. A change agent, according to Rogers (1995) is 'an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency.' (Rogers, 1995, p. 335). Change agents have to ensure that a need for change is developed, establish an information-exchange relationship, and create intent for change in the client. This intent must then be translated into action and the adoption stabilized to prevent discontinuance of the innovation (Rogers, 1995).

The second element, *communication channels* is the means by which innovations are transferred from one individual or groups of individuals to others. They may include the mass media as well as face-to-face exchanges.

Time is seen to affect the diffusion process in three ways. Firstly in the decision process, it involves the passage of time through which the adopter passes from first knowledge of the innovation to the decision to adopt or reject. The degree of innovativeness of the individual is the second factor with early or late patterns of adoption equating to the innovativeness of the adopter. Rogers (1995) uses five categories to describe adopters: innovators, early adopters, early majority, late majority and laggards. Thirdly the overall rate of adoption within a community is gauged within a time period. Hence if the number of individuals adopting a new idea is plotted over time, it usually forms what Rogers' (1995) terms, a basic S-shaped curve.

According to Rogers (1995), the *social system* refers to the 'bounded' community in which the innovation diffuses. The social system thus is made up of the 'units' which can be individuals; groups of individuals or organizations. These units represent potential innovation adopters. For example, in studying the diffusion of the specific innovation of teachers' use of computer generated reporting system, a school would represent the social system, and teachers the units within that social system. Another example could be a state school system as the social system, and schools as the adopting units.

Rogers (1995) uses the term 'homophily' to indicate the degree which individuals, within the social system, share the same or similar interest. He argues that the more similar the individuals the more likely that effective communication will occur. Some 'heterophily' is necessary to ensure that new ideas and practices are able to diffuse from individual

to individual. The structures and norms of the social system are also recognized as important components of the social system. For example in bureaucratic organizations, higher-ranking officers generally, would assume that their directives are followed when deploying a directive regarding the uptake of an innovation.

Actor-Network Theory

Actor-network theory takes quite a different perspective in its explanation of innovations. Emerging from social constructivist studies of scientific knowledge production in the 1970's (Brey 1997), actor-network theory is underpinned by the assumption that the production of scientific knowledge is not an objective exercise, (a modern notion), but rather is influenced by social factors. Actor-network theory in adherence to the principles of generalized symmetry and free association attempts to refrain from the use of labels or categories, and treats the social and the technical analytically, in the same manner. Rather than viewing innovation as a linear process moving along a predicable and visible path (e.g. scientific principles leading to technological innovation, leading to micro-economic considerations, leading to marketing and consumption), 'right from the start, technical, scientific, social, economic or political considerations have been inextricably bound up into an organic whole.' (Callon 1987, p. 86). Actor-network theory then attempts to study the innovation process without recourse to labels or categories. Seminal actor-network theory studies include Callon's (1986a) study of the development of the electric vehicle in France; Latour's (1996) study of the development of an automated transit system for Paris; Nespor's (1996) study of curriculum in university faculties in the USA; Callon's (1986b) study of the population depletion

of scallops in ST. Brieuc Bay in France; Law's (1986) study of the work of a scientist; and Latour's (1988) examination of Pasteur's success with killing microbes.

While there are now many debates about the definition and application of actor-network theory, consistently, the approach involves detailing the construction of networks of actors. Regardless of whether these actors are human or nonhuman, analytically they are treated in the same manner. Network building involves defining roles for actors, recruiting them into these roles, ensuring they remain true to these roles and finally being able to represent the alliance of these actors in space and time removed from the actors.

Just as a network builder defines roles and persuades humans to remain true to these roles, the same occurs for nonhuman actors. Indeed much effort is required to ensure nonhumans remain true to their roles. For example, the Sydney harbour bridge requires constant work to ensure it remains true to its role of providing safe transport across Sydney harbour.

When the network builder gains the alliance of actors, successfully creating a network, he/she effectively makes disparate actors equivalent. That is, an array of disparate actors now becomes unified in a network in which each of the actors (if they remain true to their roles) works toward the common goal of the network. Some actors readily accept their roles; others may require much persuasion or even coercion to accept their defined roles (Callon 1986b). In essence, network building, ensuring actors remain faithful to their role is a story of the relations of power. Here Callon (1986b) indicates the significance of network building,

> [It] is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others. Understanding what

> sociologists generally call power relationships means describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances. (p. 224)

The stability of networks is never assured. The network builder must continually ensure the actors remain true to their defined roles. To that end, if the network builder can deploy a means of being able to *control at a distance,* he or she can then attend to other matters. Traffic lights and speed bumps are examples of nonhuman actors providing control at a distance. While this control is not absolute (you can ignore both at your peril), the use of these devices does away with requiring people monitoring traffic flow and speed.

The Innovation

In this section of the paper, I will work with both diffusion theory and actor-network theory since they each offer quite different ways of approaching the study of an innovation. As suggested earlier, the introduction of information and communication technologies by Education Queensland[1] represents the launch of an innovation, the 'case' studied here. The innovation is articulated in 1995 with these words in an Education Queensland (formerly Queensland Department of Education) policy statement:

> The Department of Education, Queensland, is committed to the pursuit of excellence in learning and teaching through the integration of learning technology into education programs. (Computers in learning - Policy, Queensland Education Department, 1995.)

Following on from this publication, Education Queensland initiated several projects to support the development and progress of the innovation. These include the Schooling 2001 project which provides professional

development for teachers, and the ConnectEd project which provides the infrastructure for ICT's. These umbrella projects are in turn made up of many smaller initiatives, each with specific goals. For example within the Schooling 2001 project, the Lighthouse initiative provides funds for schools to explore and deliver professional development programs for school clusters.

In addition to these projects, many support texts were produced by EQ. These basically act as a resource from which teachers can draw information. For example the *Guidelines for the use of computers in learning* (Department of Education 1995) text provides an extensive array of examples of how teachers can use technologies in each of the key learning areas.

To ensure the success of the professional development provided for teachers, minimum standards were introduced. Effectively these outline the skills and knowledge that teachers are expected to acquire (specific to using ICT's) as a result of their own experiences or from the professional development provided by EQ. These minimum standards became incorporated into the enterprise bargaining agreement formulated between EQ and the Queensland Teachers Union in 1997. This accord is highlighted in a 1999 EQ publication:

> As professional development and technology resources become available to schools through the Schooling 2001 Project, teachers will undertake the professional development and training necessary for each individual to acquire the appropriate competencies in a **combination of school time, student-free days and outside school hours** as determined at a school level. (Minimum Standards for Teachers – Learning Technology, Education Queensland, 1999, p.1 – emphasis in original)

Additionally a host of specialists, both technical and educational advisors were made available by EQ to assist

teachers with setting up equipment and protocols in their school communities. This assistance varied and was made available both at a state level, and also within district regions. This assistance was provided by not only by EQ but also from companies such as Telstra. For example Telstra, as a provider for Internet access, set up help-desk services and conducted seminars to assist teachers to setting up email accounts and web pages.

What follows is a discussion on what can be revealed about these actions through a diffusion theory and then an actor-network theory analysis. Understandably these analyses are necessarily brief, although they do reveal something of the strengths and weaknesses of each as an analytic framework.

Comments from the Diffusion Theory

Using the diffusion concepts discussed above, the actions of EQ are clearly aimed at reducing the complexity of the innovation. By providing professional development, the degree of difficulty in using the innovation is reduced. The professional development also increases what Rogers (1995) terms the compatibility of the innovation: the degree to which it matches the values and experiences of the individual adopters. By delivering professional development in which teachers are instructed and given many examples of how ICT's can be used in education programs, the innovation is made more compatible to the experiences of teachers. Relative advantage, what Rogers (1995) refers to as the degree to which the innovation appears superior to an existing product or practices, can also be gauged in these activities. That is, through professional development programs, teachers are made aware of the benefits of using learning technologies as well as squashing fears that the integration is not as difficult as anticipated.

Teachers, as potential adopters are influenced in several ways. Firstly the assumed shared values of teachers as being caring educators, wanting the best for his/her students, is evident in the following words from Frank Peach, (the Director General of Education at that time). 'The ultimate goal for the future development of the use of information technology in our classrooms is to improve students' learning outcomes.' (Schooling 2001 - School Kit, 1997-1998, Department of Education, 1997, p iii.)

In addition EQ appears to have successfully gained the support of a significant opinion leader - the Queensland Teachers Union. The attainment of minimum standards as forming part of the Teachers' Award represents a considerable influence on the actions of teachers.

Communication channels are opened up with the production of texts and through the appointment of educational advisors in districts and nominated specialist contact personnel associated with the various projects and initiatives. Some of the initiatives (e.g. Lighthouse project) were developed precisely to open up avenues of communication between teachers within schools and school clusters.

The time factor has been addressed by stipulating a time frame for the attainment of minimum standards. Indeed the Schooling 2001 project stipulates specific time frames for the achievement of goals.

The diffusion perspective is able to reveal several features related to the innovation. These include efforts by EQ to enhance features of the innovation so as to increase its rate of adoption. It also reveals how EQ works at influencing teachers so that they are less likely to resist adopting the innovation. The provision of professional development also offers some protection from re-invention (the degree to which the innovation is modified by the adopter) of the innovation.

The missing elements from a diffusion analysis are the underlying reasons for these actions. Social actions and interactions are highlighted, but no compelling argument can be established as to the reasons behind these beyond those concerned with the innovation or the adopters. That is, the innovation is made more 'user-friendly' and efforts are made to influence teachers.

Comments from Actor-Network Theory

An actor-network analysis would view Education Queensland as having to construct a network of actors to support the innovation. To that end they have to persuade a variety of actors to take on certain roles and remain true to these roles. Specifically teachers have to be convinced to actively acquire skills and knowledge and use these in the curriculum. Secondly computers need to be persuaded to function in schools as directed by teachers. Indeed the entire innovation hinges on the computers and technologies, for if teachers are willing to perform their roles, but the nonhuman actors are not, the innovation will fail. Thus the questions are: how are these actors recruited? And what mechanisms of control are instigated to ensure that the actors perform their delegated roles?

EQ recruits and assembles actors into a network, which in turn work to recruit other actors into the network. Importantly it is both human and nonhuman actors which are configured into this network. A number of people (such as advisors, technicians), things (the Teachers' Award, computers, cables, routers, hubs and so on) and texts (policy documents, teaching guideline texts and others) are used to persuade teachers to accept a certain role: that of integrating ICT's into the curriculum.

To recruit computers (through which ICT's are mediated) and ensure they perform their delegated role they are provided with electricity, in some instances placed in air-conditioned rooms and monitored by surveillance devices. To integrate ICT's into education programs, then much equipment is provided in schools, hubs, routers, ISL cables and so on. These enable (persuade) computers in schools to act as a mediator for ICT's. It may seem odd to say that computers need to be persuaded to accept their designated role, none-the-less they have the capacity to act in ways unintended and undesired. While their role is not explicitly defined, it appears to be simply that of a tool. The computers have to be persuaded to *only* perform those tasks as required of it by teachers. To ensure undesirable web pages are not accessed, EQ enlists the assistance of filters. These also act to ensure that students adhere to their role, which involves not accessing sites deemed undesirable! Help-desk services, technicians and specialists are all enlisted to ensure that computers perform their delegated role. These personnel also serve to assist teachers to perform their roles.

Thus, an actor-network perspective would have us view Education Queensland as assembling a network to ensure that teachers actively integrate learning technologies into their education programs. Importantly, many of the actors in this network are nonhuman. Certainly we see EQ doing a lot more than merely informing teachers that they have to integrate learning technologies. What we see is EQ assembling a network of actors that have the effect of controlling what teachers do. The minimum standards ensure that certain skills are gained; the Teachers' Award ensures that teachers do attain these skills. As well schools are physically different due to the arrival of equipment.

Finally we see how computers are persuaded to perform their roles. Effectively these measures of persuading actors to accept certain roles also work to achieve control at a distance. The filters replace the need to have a person physically monitoring what web sites are accessed; the enterprise bargaining agreement stipulates that teachers must acquire the minimum standards. Education Queensland is freed-up somewhat from having to monitor each individual computer or teacher in each school in the state. As pointed out above, this control is not absolute, and networks are never stable. If Education Queensland becomes concerned that actors are not performing their roles as intended, then further action has to be instigated and other means of control at a distance would have to be put in place.

An actor-network analysis then shows that by assembling these networks of actors, control is achieved. Control can be seen to emerge from the imposing of roles on others. The computers and teachers have had roles imposed upon them, and due to the assemblage of actors, there is little room for manoeuvre, it is difficult (though not impossible) for teachers and computers not to accept their delegated roles.

Conclusion

In some ways it could be argued that diffusion theory and actor-network theory are somewhat similar. Indeed empirically, they both discuss similar factors in the overall innovation process, such as the provision of professional development. However it is the way in which they treat empirical data that the two approaches differ significantly. What I have shown here is that actor-network theory has the potential to provide a broader understanding of the

innovation than the cause and effect analysis that the diffusion model yields.

Actor-network theory conversely does not rely on a cause and effect approach. Rather the analyst simply documents interactions and negotiations from which an understanding of the innovation process is arrived at. In this way the reasons behind how and why a particular 'cause' has emerged, what negotiations led to the innovation being in this form and then how that form effected the innovation, are able to be revealed. But the analyst does not *a priori* determine 'cause' and then search for an effect, rather an overall understanding is arrived form meticulous documentation of events of the innovation under study. Indeed, Rogers (1995) concedes that the diffusion model seldom moves beyond a cause and effect approach: 'We should increase our understanding of the motivations for adopting an innovation. Strangely, such "why" questions about adopting an innovation have only seldom been probed by diffusion researchers.' (p. 109).

The scope for an actor-network theory analysis to yield a broader understanding can be seen in relation to the provision of professional development. A diffusion analysis would posit that the provision of professional development could cause the effect of reducing the complexity of the innovation. An actor-network theory perspective would argue that the provision of professional development is a means of controlling the way in which the innovation is implemented. That is, by teaching teachers *how* to use these technologies, there is less scope for them to use the technologies *as they wish*. Actor-network theory has the potential to reveal what a collection of diffusion 'cause-and-effect' actions produce, in this case control over what teachers do. Thus diffusion theory does not appear to be able to go beyond a cause-and-effect treatment of events,

whereas actor-network theory unearths the motivations that produce the cause-and-effect events. In this case, actor-network theory reveals attempts at seeking control at a distance. That is, EQ assembles a network to ensure a particular goal is achieved (the innovation is implemented in the manner intended) and that EQ does not have to continually monitor the actions of individual teachers in performing a particular role.

The diffusion theory, as Rogers (1995) warns has a weakness due to the tendency toward a pro-innovation bias: the implication that a given innovation ought to be adopted and therefore will diffuse through a social system. This is not always the case, Rogers (1995) uses the examples of cigarettes, nuclear weapons and crack cocaine. This bias is problematic in that it can sometimes lead researchers to make unnecessary assumptions that the innovation should be adopted. Research underpinned by such an assumption then influences significantly the way in which the research is conducted. Actor-network theory, while obeying the principle of agnosticism, can provide a means of avoiding this pro-innovation bias (to the best of the researcher's ability.) Thus instead of being 'blinkered' in a research approach of ascertaining why things did or did not happen in a particular way, an actor-network theory approach is primarily concerned with documenting events as they occur or occurred. It is from this empirical evidence then that an understanding of the innovation arises, what factors influence the trajectory of the innovation. And to be sure, regardless of whether these influences are either social or technical in nature, both are treated in the same manner.

Actor-network theory avoids an essentialist notion that innovations possess an 'essence' which is responsible for successful or unsuccessful diffusion. While the diffusion theory examines attributes of the innovation and frame the

innovation's success or failure in terms of those attributes, actor-network theory does not make the judgement that the innovation is inherently 'good' or 'bad', but simply reveals the influences that contribute to the fate of an innovation.

As well, the diffusion theory is unable, analytically, to incorporate nonhuman entities to the extent of actor-network theory. To assume that computers and other nonhumans, such as information and communication technologies will perform as desired is to dismiss the extensive work involved in ensuring that these actors do perform as required.

This paper then has served to support the use of research framed by actor-network theory. It argues that we need to move beyond approaches that offer a limited view on the innovation processes such as that offered by Rogers (1995) diffusion theory.

Endnotes

1 Education Queensland prior to 1998 was called The Queensland Department of Education.

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