27 Design Research and the Diffusion of Innovations

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Introduction

Dilemmas associated with moving effective curricular and pedagogical practices and programs into broader use among educators have persisted for years. Acknowledgment of these problems, referred to variously as issues of dissemination, knowledge use, scale up, technology transfer, or diffusion, have given rise over the years to organized efforts to reverse gaps between research evidence about effective education on the one hand and what is practiced on the other. For example, the National Science Foundation created Teacher Institutes and used commercial publishers to disseminate curricular innovations beginning in the late 1950s and on through the 1980s. The U.S. Department of Education instituted Project Innovation Packages, the Pilot State Dissemination Project, the Research and Development Utilization program, the National Diffusion Network (Raizen, 1979), and the Educational Resources Information Center Clearinghouse, all in the 1970s. Evaluations and reviews have found some of these efforts unsuccessful (Crandall, 1982; Horst et aI., 1975); others were determined to be successful, but expensive or nonsustaining (see Louis & Rosenblum, 1981; Sieber et aI., 1972; see also Hutchinson & Huberman [19931 for a review of this set of large-scale efforts at educational change). Most efforts to diffuse innovations are unsuccessful. If graphed in cumulative fashion over time, a no-growth curve in adoption would be evident, as illustrated in Figure 27.1.

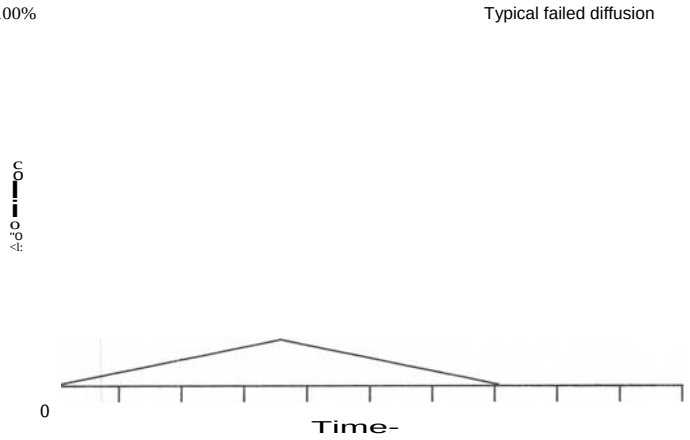

Figure 27./ Most Purposive Efforts to Spread Innovations Fail. Diffusion is the Exception, Not the Norm, in Social Change.

As the educational system has grown in the United States, so, too, has the research base about students as learners, teachers and teaching, and the joining of the two in classrooms. In particular, the special challenges of science and mathematics education have been studied extensively (Ball et a!., 2001; White, 2001), resulting in what some researchers term "scientific teaching" (Handelsman et a!., 2004). Yet the translation of evidence into practice-the achievement of broad impact with evidence-based practices, programs, and policies-proves more elusive than ever (National Science Foundation, 2002). This divide is of great concern and an important element of higher education research agendas (Kezar & Eckel, 2000). The gap is exacerbated by the separate tracking of students in training to become researchers and students in training to become teachers, which inhibits the degree to which researchers understand practice and the extent to which teachers understand research (Neumann et a!., 1999). And it persists, in part, because information or direction from a distant, outside, change agent is insuf· ficient to affect teachers' practice, which is more the result of locally bounded systems of influences (Fullan, 1985, 1992). Yet, even when changes in practice occur and endure, they do not result often in fundamental reorientation of how teachers think and, thus, construct classroom engagement (Ball, 1990; Cohen, 1990).

It is in this research and application tradition that we assess the diffusion potential of design research. In so doing, it is important to note that design research is not a curricular or pedagogical innovation, but a new method of educational research about practice. Design research is also more than a method. Design research is an approach to the development of theory and method based in the real-time, formative experience of implementing, assessing, and improving classroom practice, classroom research, and classroom learning. It is a combination of quite disparate methods used in certain ways; thus, it is perhaps more an innovation of how one conceptualizes research (commonly referred to as a research design) than of how one collects and analyzes data. We suggest that design research embeds epistemological assumptions about knowledge and knowledge use that more discrete methodologies do not. These somewhat radical characteristics of design research undoubtedly contribute to its attraction to certain educational researchers; these characteristics also will present special challenges to its diffusion among others.

An organizing question for much design research is: "How does the enacted design of a particular classroom experience affect learning outcomes?" Students, teaching assistants, and teachers participate collaboratively in design research with researchers, so that advances in educational research may parallel advances in educational practice and the reality of practice can inform and improve the reality of research as much as we hope that evidence-based research will inform practice. As a methodology, design research is carried out in real practice settings, holistic in the variables and cases studied, causal in attribution, and intended to be modified in real time as implementation proceeds. These characteristics combine to produce an innovation of considerahk complexity.

What is the likelihood that the innovation of design research will move beyond the community of practicing educational researchers who are enthusiastically creating, testing, critically refining, and improving this model approach to educational theory, method, and classroom practice? Which obstacles to diffusion can be foreseen reasonably for design research? And what sort of strategy would facilitate not only the c1assroom-to-classroom transfer of design research, but also a more general and more rapid spread of this class of educational research approaches to improvements in educational research and practice? We address these questions throughout this chapter.

This chapter is rooted in the interdisciplinary literature of the diffusion of innovations.

Many educational innovations, including those of classroom pedagogy, currind:l, ,1ı1d instructional technology, have been studied from this theoretical perspective ı (Ibll ,\c. Cohen, 1996; Fishman et a1., 2004; Hutchinson & Huberman, 1993; Mintrom, 1')':)7; Snyder et a1., 1996; Stahl, 1999; Wollons, 2000). Here, like Bannan-Ritland (2003), we apply certain, diffusion-based concepts to the class of innovations known as design research, design experiments, design studies, or, simply, design (Cobb et a1., 2003; Kelly, 2003, 2004) for the prospective purpose of overcoming or counteracting perceived uncertainty.

Our purpose in this chapter is to: (a) introduce the diffusion of innovation paradigm and explicate how, in the case of consequential innovations such as design research, diffusion operates, (b) highlight the role of uncertainty in the diffusion process as an obstacle to diffusion, (c) assess the prospects for design research in light of what is known about diffusion and uncertainty, and (d) pose questions that can facilitate a purposive diffusion strategy for accelerating the spread of design research as a new and effective methodology for use by educational researchers.

What is Diffusion?

Rogers (2003: 5) defines "diffusion" as "the process in which an innovation is communicated through certain channels over time among the members of a social system." An *innovation* is anything that potential adopters perceive to be new, inclusive of new ideas and beliefs, explicit and tacit knowledge, processes and protocols, tools and technologies, even value belief systems. Some educational researchers refer to diffusion as scalability (i.e., Fishman et a1., 2004); researchers in management use labels such as transfer.

Some innovations spread without apparent effort. These innovations tend to be ideas that do not require much, if anything, in the way of attitude or behavior modification. For example, studies of the diffusion of news document rapid and broad knowledge of events. In such cases, diffusion occurs fast because only a minor amount of attention is necessary for people to know about the event. Other innovations may be complex and expensive, such as new corporate production systems. They spread because of bandwagon effects in which managers or administrators are afraid of lagging behind competitive rivals or because the decision to adopt is decoupled from responsibility for implementation. In both cases, diffusion can be extensive but use of the innovation curtailed.

Diffusion can be a fascinating topic of study because the literature includes many examples of advantageous innovations that do not achieve widespread use, even after many years and even when campaigns are conducted to publicize them. This is so even for highly effective, "best practice" innovations that have demonstrated empirical advantages compared to alternative ways of achieving the same ends, and it is so even when studying diffusion within the same organization, where the rate of adoption might be expected to be more rapid than adoption across separate organizations. Concerning innovation diffusion, what is best and what is used are frequently different. For example, in the field of health promotion, a computer simulation by Stover et a1. (2002) found that if proven programs in HIV/AIDS prevention were adopted worldwide, 29 million new infections could be prevented by 2010. In the field of education, Fishman et a1. (2004) argue convincingly that effective innovations in the learning sciences have not spread widely into classrooms.

Cases from the diffusion literature do not stop at highlighting effective innovations that do not diffuse; we have cases of innovations with very important implications for

rhl' adopters that spread before the communication of any information about their dkctiveness, such as in the rapid imitation of strike behavior by eighteenth-century coal miners (Conell & Cohn, 1995). The business literature is rife with stories of corporations adopting workplace and managerial fads and fashions that rdlect large investments of money and time. University administrators, too, engage in faddish behavior frequently (Abrahamson, 1991). Further, there are studies demonstrating rapid rates of adoption of ineffective innovations, such as the DARE (Drug Abuse Resistance Education) program (Ennett et aI., 1994). Clearly, there are factors other than effectiveness that account for diffusion, such as the alignment between technologv-based teaching innovations and organizational conditions such as culture, capabilities, and policies in schools (Fishman et aI., 2004). Stated differently, although, typically, effectiveness is related positively to adoption decisions, other factors can be correlated more highly with adoption. Social influence is one of those factors.

So diffusion is a communication process in which information dissemination is necessary but not sufficient to produce change and a process in which the qu::dity of the innovation is merely one among multiple factors that determine adoption behavior. Scholars dating at least to Georg Simmel and Gabriel Tarde 100 years ago theorized about imitative behavior at the level of small groups and in communities and the relation between these microlevel processes to macrolevel social change in which secrors, networks, and cities change. In the 100 years since, researchers have conceptualized diffusion at the macro sociological level of sector, system, national, or state change (Casterline, 2001; Cole, 1998; Garrison, 2001; Grubler, 1996; Viswanath et aI., 2000); the social psychological (i.e., communicative) level of local relationships and how those linkages affect adoption patterns (Rogers & Kincaid, 1981; Sen,I969); or the psychological level of how individuals perceive innovations (Manning et aI., 1995).

The paradigm is interdisciplinary, theoretically informed, and practice-based, with empirical studies dating from the 1940s when rural sociologists first sought to understand the reasons for the adoption of hybrid corn in two farming communities in Iowa ("What distinguished earlier from later adopters?" "Why did the rate of adoprion change when ir did?"). Key publications have highlighted the unique contribution of diffusion as an explanation of social change above and beyond the variance accounted for by economic and structural variables; the importance of social influence by opinion leaders rhrough interpersonal networks; presrige as a morive for adoption; till' unintended consequences of adopting and implementing an innovation; the importanCl' of potentia] adopters' perceptions to their eventual adoption decisions; the low correl ation between measures of adoption and implementation when organizations are the unit of adoption; the usefulness of a social network perspective for understanding diffu sion; and the rationality of adopters' seemingly irrational decisions (Rogers, 2003) Recent diffusion studies have traced and explained the spread of kindergartens across cultures throughout the world (Wollens, 2000); the spread of schools of choice policies among most of the 50 states (Mintrom, 2000); the diffusion of tobacco control throughout North America (Studlar, 1999); the spread of enterprise zones (Mossbergl'l, 2000); and the adoption and institutionalization of inclusion and participation ıı community health system planning (Dearing et aI., 2001).

Across most of these studies, key variables are found to affect the rate of adoption ‹ıı innovations. Several of these variables are especially important when considering t hl adoption and widespread use of design research. One variable is the type of decisi(lll made about an innovation associated with design research, a second is the perceivt'll attributes of design research, and a third is the communication channels, specifica II \. intnpcrsonal communication, necessary to encourage adoption.

Research: An Optional and Consequential Adoption Decision

The social and professional structure of higher education affords faculty great latitude in the choice of pedagogy and research practices. Many of the decisions that faculty make about their practice are "optional innovation decisions," where the choice to adopt or reject an innovation is made by the individual independent of the decision of the other members of the social system. Other forms of innovation decisions are authority decisions, where relatively few people in the social system make an adoption decision that impacts many others, and collective innovation decisions, where consensus among members leads to a decision to adopt or reject an innovation. Design research is an optional innovation decision; that is, faculty members in higher education and teachers in kindergarten-through-grade twelve *(K-12)* systems make their own decisions about whether to engage in design research independent of their colleagues.

Unlike many innovations that require little effort and have minimal impact on the adopters' practice, design research purports to replace routinized practices and has great potential consequences for the adopter. As such, it is a "consequential innovation." Consequential innovations that disrupt or change practice often require considerable information-seeking and advice-seeking, trial-and-error learning, training, and modification to suit an adopter's needs best. Design research has important implications for the adopters' practices and, thus, requires careful consideration.

The more consequential the innovation is for practice, the higher the uncertainty about whether, and how, we should seek more information, gather opinions, and experiment with the innovation. Uncertainty associated with a consequential innovation produces cognitive dissonance in the mind of a potential adopter. Dissonance is an awareness that how we achieve certain objectives might be suboptimal and improved through the use of an alternative (the innovation). Individuals who experience cognitive dissonance often seek additional information to resolve dissonance to a state of cognitive consistency.

When confronted with an innovation perceived to be consequential, potential adopters first experience operational uncertainty about what the innovation is and what it does, often expressed as the innovation's presumed benefits or its operating principles. Potential adopters also experience evaluative uncertainty. They have questions about the costs and outcomes of using the innovation (efficiency and effectiveness), becoming more explicitly evaluative as they approach the point of making a decision about the innovation. Typically, operational uncertainty precedes evaluative uncertainty.

Design research decisions require individuals to gather a great deal of information to reduce the uncertainty associated with this individual and consequential decision. Often, the early operational uncertainty of potential adopters can be reduced or satisfied with packaged impersonal information that identifies clearly what design research is and why it works. Central to reducing this early operational uncertainty is clarity about the innovation's attributes, a point we address later in this chapter. Mass media channels such as websites can transmit effectively information that reduces operational uncertainty.

Evaluative uncertainty associated with the personal advantages and disadvantages of the innovation typically requires a form of interpersonal communication or social influence to assuage the concerns of the potential adopter. Social influence may occur through different channels of communication, although, for consequential innovations, interpersonal communication in the form of word of mouth, personal observation, or social modeling is often considered key to diffusion (Bandura, 1986).

Two dilemmas, then, must be overcome if one WJnts to accelerate optional and consequential adoption decisions. One dilemma is portraying the innovation so that operational uncertainty is reduced. We can meet this dilemma by focusing on the attributes of an innovation that are found to impact its likely adoption. Typically, this type of portrayal is embedded in information for one-way communication. The second dilemma is the induction of social influence. When an innovation is consequential such that it evokes a high degree of perceived risk or uncertainty (such as a reorientation to the conduct of research), local, informal, opinion leadership is often sought to resolve cognitive dissonance. Triggering social influence based in the existing relations in a social system is the key to intervention-based diffusion.

Operational Uncertainty: Assessing Design Research Attributes

Several recent authors, most of whom arc advocates or adherents of design research, have cOll1mented on the conceptual, Jefinition;:t1, or operational lack of clarity of design research (Collins et aI., 2004; Dede, 2004; Kelly, 2004). A lack of clarity about what design research is does not constitute necessarily a problem for its early adoption. Innovations in an early stage of development arc often ill defined in parall1etn, purpose, outcomes, and language, especially when an innovation is being contributed to and codeveloped by loosely coupled networks of participants. However, such conditions usually must be resolved for diffusion to occur. Resolution must occur first among the developers of the innovation, those researchers and educators who arc expnimenting with design research. Then, once shared agreement and clarity are achieved, the innovJtion can be comll1unicated to a broader audience of potential adopters. Further change to the innovation is typical, but users change innovations only after they have adopted them initially-and adoption depends, in part, on clarity.

Clarity about the attributes of design research is key because the perceived attributes will determine the information that potential adopters have available to them to decrease the operational uncertainty. Here, we consider design research in terms of codified attributes of innovations. We suggest that attributes function as barriers and catalysts to the diffusion of design research at this point in its development and discuss how demonstrations of design research affect its spread in terms of reducing operational uncertainty. Next, we turn to a considnation of social influence and its role in relation to the dispersion of design research.

How is design research pnceived by potential adopters? In lieu of empirical data, we compare perceptions of design research based on publications by and discussions with educational researchers who conduct design research with what is known about the general relationships of the perceived attributes and the rate of adoption of innovations. Relative advantage, compatibility, complexity, trialability, and observability are attributes of innovations shown to explain variance in the rate of adoption. Evidence in the diffusion literature for the first three of these attributes is particularly well established. We use these five attributes as one means to discuss the potential diffusion of design research.

Relative Advantage

This attribute is one of the strongest predictors of an innovation's rate of adoption. Relative advantage can be considered as a ratio of the expected benefits and the expected costs of adoption. The higher an innovation's perceived advantages, the more rapid its adoption. Costs and benefits typically associated with innovations that can be

extended logically to design research include social prestige, 1lI0l1l't:ll'y ,ll1d 11IlllI! If 1111'\,11 ~ costs, immediacy of reward, and a more nuanced and better dOCllllll'l1lnl ,IP(1I",1\ It In the study of learning.

Higher education has a finely tuned order of merit and prestige :11111111/'. 11l1l\'("r~llIf' and colleges (Becher & Trowler, 1989). The majority of authors of articks ,t!lout d"'df;ll research work at Carnegie classification "doctoral/research universities: exI ('1"1 \ I',," such as the University of Chicago, Harvard University, and the University of Cali/of 111,1, Berkeley. Potential adopters often consider high-status individuals and instituriOIlS ,I~ legitimizing attention to an innovation, meaning that it is normatively congruel1t III attend to messages about it. Thus, design research should benefit from such byline association and the fact that many of the preliminary studies and formative tests lIf design research are occurring at these universities. Faculty at institutions of like or lesser prestige than these initial institutions may be motivated to adopt design research as a means to elevate their own social prestige, so social prestige is an aspect of relative advantage that design research has in its favor.

However, other aspects of relative advantage are likely to present challenges to the diffusion of design research. Although the monetary costs of design research are likely modest in that it does not demand the equipment and facilities that new research methods do in physics, biochemistry, and other sciences, in the educational research community, design research is resource-intensive, perhaps extraordinarily so. Design researchers collect large amounts of data of multiple types in order to create a dynamic and contextualized understanding of the learning process and its outcomes. It can take considerable time and specialized knowledge to carry this out, especially as the research team moves into the process of interpreting of results, where divergence and convergence across the findings of different methods must be accounted for and explained. As noted recently, "design experiments tend to be large endeavors with many different participants, all of whose work needs to be coordinated" (Collins et al., 2004: 19). Like other, triangulated, multimethod, research designs that demand additional iterative layers of analysis and interpretation (lick, 1979; Kidder & Fine, 1987; Morgan, 1998), design research may require much more time and effort than faculty allocate otherwise to studies based on classroom observations, surveys, or personal interviews. Although the knowledge gained may justify the time and energy costs, the costs are very real to faculty and teachers, for whom time is often considered a most important resource.

A second aspect of time that we expect to be salient to potential adopters of design research is the time lag between entering the field and publication of any resultant work (immediacy of reward). Compared to the use of other research methods and designs, design research likely requires a longer time between initiating a research project and submitting research findings to journals or conferences. More methods of data collection are involved; therefore, more interpretation and resolution will be required in analysis. This length of time between engagement with the innovation and reward (publication) is another, potential, negative aspect of relative advantage that it is reasonable to associate with design research. The time lag between entering the field and publication is especially troublesome for junior {acuity facing a reward system that continues to value publication quantity more readily than publication quality.

Finally, concerning relative advantage, design research as an innovation holds a lofty promise of bringing together quantitative and qualitative research epistemologies and methods in the pursuit of more sophisticated and better" learning about learning." Few academics, we suggest, will argue with the pursuit of such a promise, other than those most taken with the beliefs of William of Occam. Parsimony in explanation is unlikely to be a strength of design research. But, from the perspective of educational researchers,

we expect the promise of design research to be a powerful incentive for potL"lllLd adopters to attend to messages about it and consider its advantages and disad":l11tag,'"

Compatibility

When adoption decisions arc voluntary, that is, when the choice to adopt rests with thl' person or unit who will implement and use the innovation (i.e., "the users are dll choosers"), the perceived compatibility of the innovation with the potential adopter', values, past experiences, and needs is of pa rticuh I' importa nce. The Illore compatible :111 innovation is with the ways in which the adopter thinks and behaves already, the morl' likely adoption is. Aspects of design research such as the inclusion of Illultiple imerestnl parties and a strong focus on methodology are likely to be perceived as compatible 11\ potential adopters with how they think and behave already and with what they vailit' as scholars. However, design research has been labeled as "under-conceptualized" (Dede, 20(4) and lacking in strong theoretical foundations (diSessa & Cobb, 2004L Researchers who hold theoretically derived research and theory-testing as the found:1 tion for their work may not view design research :lS compatible (yet) with core researd, values. Design research is compatihle with the experiences of many education:ll researchers and K-12 research faculty because the innovation does not involve neceSSar ill' new methods of dara collection and analysis but, rather, new combinations 01 ex isti ng methods. We expect that design resea rch ma y not stri ke ma ny ed ucation:lI rese:uchers as all that different from what they have been doing until they become well acquainted with it. Then, the difficulties of the process and interactive nature of desigll research will impress them.

COlllpatibility also encompasses the extent to which an innovation meets a felt need.

Tht: perceived need for design research may be the most troubling aspect associated with compatibility. Are educational rest:archers and teachers dissatisfied with current research methods and practice? The problem of compatibility may extend beyond researchers and teachers themselves, too. As Dede (2004: 114) put it bluntly, "neither policymakers nor practitioners "vant what the DBR Idesign-based research | community is selling right now." And although policy-makers and practitioners Illay not be the primary adopters-that would be faculty-faculty needs do not occur in a vacuum. II faculty perceive little support from teachers or funding sources for this work, faculty "need" is truncated.

Complexity

An innovation is complex to the degree to which it is perceived as relatively difficult to understand and use. An innovation low in complexity is adopted more rapidly. To those familiar with classroom-b;lsed research or practice, design research may not be perceived as an unusually complex innovation in concept, but, in practice, proposed approaches to design research require more effort than anyone human can provide (Collins et aI., 2004). A team is required, and what it is required to do is inordinately complex. The research design is malleable for the immediate improvement of practice in action; little about design research is intended to be static. Some requirements of design research embed all the indeterminancy of dynamic interactive systems models. The degree of complexity of such modeling is well beyond all widely used educational research methods. The likely perception that it is atypically complex will contribute centrally to perceptions of uncertainty about how design research will work in practice.

Adding to the complexity of design research is a lack of standards to refer to when

making decisions about its use. This innovation is heing dl·\,(·llll'l'd ",dl; 1111) ~I,oitl.lftl that make other research methods recognizable, accessihle, .tlld (',II II"""", IL j('t.t;:l',he,", are being contested actively still.

Trialability

The extent to which a potential adopter can experiment with an innovation IwllllL' ,1I1 adoption decision is referred to as testability. An innovation that can be lIsed 011 .111 explicitly temporary basis without negative repercussion or that can be phased-ill gr:ldually or in terms of its component parts will be adopted more rapidly. We expect design research to be perceived as high in testability because the innovation is of low initial monetary cost, meaning a low barrier to entry, and design research's multiple components make it easy for adopting researchers to implement pieces of design research one component at a time. We also expect that because some accessible archives document the design experiment process, their use could serve as a means by which potential adopters engage in trials of design research without having to invest the time to collect their own data from the field.

Observability

If the results of an innovation are visible to potential adopters and providing that the results are positive, the innovation is more likely to be adopted than if the results are not observable. Seeing is believing. In education pedagogy and research, observability is a challenge. School building design tends to work against observing success with an innovation in a colleague's room during the project, thus limiting observation to those teachers who are members of a research project (Zaritsky et a1.). How, then, can those engaged in design research increase its observability? Zaritsky et al. (ibid.) indicate the need to go beyond the traditional dissemination models of text and talk to the use of media on DVDs in the form of scientific visualization. Case studies, such as those used by Collins et al. (2004), can help to make design research more observable. And, as we discuss below, observability can be achieved well through exemplary demonstrations.

From an innovation perspective, design research is complex, its relative advantage is unclear, and, although it is likely to be compatible with the values and experiences of potential adopters, the need for it is not well established. Potential adopters can tryout components of design research and it is possible to observe it although this may not be easy. Essentially, design research is in a prediffusion stage, still meeting the objectives of establishing proof of concept (efficacy), effectiveness (internal validity), and robustness or generalizability (external validity). Communicating the continuing and uncertain results of a design experiment-akin to rushing the product to market-will not decrease the onlookers' operational or evaluative uncertainty, and it may heighten both. Time is required for an innovation to be developed through a research and development process. We believe that demonstration warrants special attention in thinking about design research in general and in reducing operational uncertainty in particular.

Innovation demonstrations can be of two types. An experimental demonstration is a field test of an innovation carried out at full scale under real-world conditions to test external validity by varying the setting, the participants, resource availability, implementation protocol, and the methods by which outcomes are measured. An example is design research carried out by a team of educational researchers, a teacher, and students in a classroom. The objective might be to learn about the design research process through observed data about an expected (theoretical) model of relationships. This prediffusion

activity is key not only for the formative improvement of an innov:ltion, but also more fundamentally for the determination of whether a p;lrticul;lI' innovation should lw diffused. The purpose of an experimental demonstration is both to prove the innovation's worth in practice and to improve it through iterative adjustment. Experimental demonstrations help innovation developers reduce their own operational uncertaintya necessary precursor to reducing potential adopters' operationaluncertainry.

Once external validity (an acceptable degree of robustness) h;ls 11L'l'n established through applying the approach at second-generation sites, a second type of demonstration is warranred. An exempLHY demonstr;ltion is a !1LTsu:lsive event calculated to influence adoption decisions to increase the likelihood of diffusion. An exemplary demonstration is not staged for the purpose of merely disseminating information; rather, the objective is to showcase an innovation in a convincing manner. Exemplary demonstrations increase the likelihood of diffusion p:lrtly by making a costly, worrisome, and complex innovation more underst:1I1lhble, observ;lble, ;1I1d predictable in outcomes. Tlbk 27.1 illustrates the distinction between experilllent:ll :lIld exemplary dem onstra ti (llIS.

Lack of clarity about the purposes of demonstr:ltions is a frequent culprit in the nondiffusion of innovations. A disconfirmed hypothesis th:lt k:lds to :1 design improvemenr is a positive result in an experimenral demonstr:ltion; in :In exempLlry demonstration, such an outcome is Iloise th:lt will Ie;ld to perceptions of highcr, not lower, uncertainty among potential adopters. Thus, the rC:ll-timl' conduct of design research in a classroom is not the time for showing off what is going on, just :lS :ll1owing or encouraging others to view and/or use ongoing website inform;ltion or preliminary results from design research studies is a mistake if the intL'nr is diffusion. If the point is to spread the word, then teachers and researchers should be invited to a classroom or website only when the likelihood of surprises has passed.

When academic researchers who have developed an innov:ltion communicate its pro cess and outcomes to knowledgeable experts (such as other teachcrs ;lnd education:ll researchers who know hrsthand the opportunities and constraints of c1:1ssroom practiu' :1I1d how it is embedded in school and school district administr:ltive structures), the)' talk as they were trained to do: with qualification, with questions, with emphasis on what is not known, and by chrifying the limitations of knowledge about the inllovatioll (Dearing et a I., 1994). The complexity of design resea rch as a Illethodology will engendn many such remarks. Despite how enthusiastic the developer Illay feci about design

Ta/lle 27./ C01llparison of the Main Attributes of Experimental Demonstrations and Exelllpla,", De1llonstra ti()JlS

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1 Purpose	To test the fe;lsihility of an innovation under operational conditiollS	To illustrate the utility 01 the innovation to potential ;ldoprers
2 Attitude of demonstration managers toward the innovation	Skepticism	AdvoclCY
3 Desired visibility of the demonstration	Low	High
4 Control ot possible intervening variables	Moderate control for rhe purpose of modeling the process	High control

research, the impression of the onlooker will be colored by what he or she is told and can see. The image is likely to be a hazy one in which high potential is m3sked and muted by the reality of difficult implementation and preliminary results. Design researchers should continue with experimental demonstrations, but they need to be careful not to treat them as exemplary demonstrations.

Evaluative Uncertainty: Social Influence and the Use of Design Research

Uncertainty 3bout what the innovation is and what it does (operational uncertainty), as just discussed, often can be reduced through one-way communication or demonstration. Uncertainty associated with the personal advantages and particularly the disadvantages of the innovation (evaluative uncertainty) typically requires a form of interpersonal communication or social influence to persuade someone to adopt it. Communication about the innovation by local, informal, opinion leaders (near peers) who arc respected, knowledge3ble, trusted, and accessible triggers a positive or negative resolution to cognitive disson3nce by others, reducing their uncertainty 3bout the innovation's worth. The nonrandom unequal distribution of social influence in the form of local informal opinion leaders is a strong and reliable filter through which consequential innovations predictably must pass if they are to g3in widespread adoption in a social system.

Especially for innovations high in perceived risk (including the extent to which resources may be reduced or threatened) or evaluative uncertainty, diffusion occurs through an interpersonal social process in which pre-existing influence among people or organizations alternately facilitates and impedes the rate and extent of spread. Factors other than interpersonal influence can start and complete diffusion processes (Kerckhoff et 31., 1965), but it is interpersonal influence that accelerates rates of diffusion. When consequential innovations spread rapidly, it means that they have been accorded a high degree of approval by influential people within a social network, in which members are connected to each other through patterned flows of face-to-face and mediated interpersonal communication, or in a social sector, in which members do not comprise an interconnected network but do share common demographic, situational, and/or behavior31 characteristics (Katz & Lazarsfeld, 1955; Castro et aI., 1995; Mayer & Davidson, 2000; Milltrom, 1997; O'Brien et aI., 1998; Puska et aI., 1985; Stokes-Berry & Flowers, 1999; Weimanll, 1994).

Opinion le3dership is the reason why diffusion can be such a very efficient process to jump-start: 3n innovation source or sponsor need only communicate an innovation to a special small subset of all possible adopters for the innovation to spread through the social system. Opinion le3ders are individuals who are able to influence informally (as opposed to exercising authority over) other individuals' attitudes and beliefs. Opinion leaders, through communicating or social modeling, do the rest as long as (a) their attitudes are favorable toward the new practice, and (b) others identify the opinion leader positively with the innovation (Valente, 1995). Alternatively, and indeed more commonly, when influential people have a low opinion of an innovation, it is their avoidance of it (passive rejection) and/or their opposition (active rejection) that impedes its spread (Leonard-Barton, 1985).

Strictly speaking, opinion leaders are not peers. The importance accorded to their opinions makes them somewhat heterophilous to others-a near peer. Opinion leaders tend to be accessible and 3re in direct or observable social distance with followers. They are leaders in an informal and local sense-that of being advice-givers and examplesetters for people they know. Opinion leaders take risks on innovations to the extent

that the communication networks of which they are members support risk. More often, they are conservative in their orientation toward innovation; their functions are those of maintaining, protecting, and helping the members of their interpersonal network concerning a certain subject such as research about students' learning.

For new ideas generated from outside their interpersonal network, opinion leaders are gatekeepers, allocating attention and then evaluative judgments for the benefit of their network members. They are in a position to know of outside innovations given their greater number of interpersonal and media contacts, especially with sources outside their network. The approval of opinion leaders is crucial for introducing new ideas into communication networks and lending those ideas credibility. The spread of those ideas through peer-to-peer communication follows opinion leaders' approval. Influence spreads through other processes, too, including structural equivalence, in which people of equivalent rank or function in different organizations or systems adopt innovations at the same times because of common patterns of information exposure rather than interpersonal communication (Burt, 1987, 1999); through other channels, namely, specialty and mass media, through which various social effects such as social modeling may operate (Hornik & McAnany, 2001; McAlister, 2000); and through the depiction of problem solving and efficacy. But, as the perception of consequence rises, the reliance on known and trusted interpersonal sources of evaluative judgment (which reduces evaluative uncertainty) rises.

The two-part, social influence question for design research, as for any consequential innovation, is this: Who is associated with the design research, and, more to the point, how are they regarded by educational researchers and teachers who constitute its potential adopters? In the diffusion paradigm typology of innovators (the first 2.5 percent to adopt), early adopters (whose 13.5 percent includes the 3-5 percent of opinion leaders), early majority and late majority (who comprise 68 percent of potential adopters), and laggards (the more cautious 16 percent), where do the current experimenters and demonstrators of design research fall? Are they opinion leaders for others? Or, as we expect on the basis of their current experimentation, are they less norm-bound and more venturesome? Indeed, although those who are modeling the use of design research may be innovators, we expect that many of them would be categorized more accurately as developers-the creators of the innovation-and be even further removed sociometrically from being able to convert a system toward the adoption of an innovation.

The social influence point here is simple. The ability to influence directly through advice-giving or example-setting does not accrue normally to innovators (the first to adopt), let alone to developers (the creators of innovations). Their functional roles in the diffusion of innovations is something other than social influence: developers create the new and the different; they are generative sources of change. Innovators do not so much create as tryout eagerly *without regard for what others think about them.* Very often, the use of an innovation by developers and innovators is a sure sign to the majority of potential adopters that the jury is still out, that the innovation is not ready, that the use and outcomes of the innovation are too uncertain. If current users of design research are seen by the majority of educational researchers as developers and innovators, then it is too soon to expect diffusion. Design research will spread when other educational researchers-those who adopt research methodologies and teaching pedagogies early and who are sought out for their opinions on such matters--come on board ..

Making the assumption that those who are motivated to contact us and inquire about what we are doing are also those who are socially well positioned to influence others' perceptions is close to folly. Diffusion studies have shown that innovators and early

adopters have their own reasons for early adoption, which can be counterproductive to diffusion. Opinion leaders constitute a small proportion of system members (often about 5 percent), so random approaches to recruitment, volunteerism or self-selection, marketing or advertising, or defaulting to positional authority such as a dean will miss the mark in jump-starting diffusion about 19 times out of every 20 attempts. If the early adopters are seen by others as iconoclasts and loners, they may be damaging the innovation's chances for achieving scale.

This critique of design research is by no means unusual. Rarely is thought given beforehand to whom to involve in using an innovation and when to do so for the purpose of encouraging others to follow along. The authors' experience of working with people and organizations who are trying to diffuse innovations shows that an appreciation for this simple idea is widespread, but only subsequently, when it has been pointed out.

To summarize, operational uncertainty is reduced through knowledge or expertise that is gained largely through the one-way communication of information. Evaluative uncertainty requires persuasion that occurs through two-way communication through pre-existing channels of social influence in the form of informal, extant, local, opinion leadership. Social influence plays a critical role in the positive adoption decision to try a new practice. Information alone, in whatever form, is insufficient to move the individual toward a positive decision or even serious contemplation of the costs and benefits of an innovation when the innovation in question is consequential to the potential adopter (Bero et aI., 1998; Evans et aI., 1986; Jacoby & Clark, 1986; Kanouse & Jacoby, 1988; Lomas, 1991; Lomas et aI., 1989; Mittman et aI., 1992). Talking is key (Rutenberg & Watkins, 1997). And it is not talking with anyone; it is talking with a person whom potential adopters believe to be expert and trustworthy. If someone other than an opinion leader advocates or serves as a social model for design research, potential adopters are less likely to make positive adoption decisions.

The fact that the few can influence the many is the special promise of diffusion, the so-called" diffusion effect" that produces the nonlinear (logistic) curve that characterizes the pattern of innovation adoption over time; that is, "successful" diffusion as depicted in Figure 27.2.

In some ways, the history of the diffusion of innovation is one of increasing inequities. Those persons with resources and information reap the benefits of innovative programs early relative to others; those most in need of the benefits adopt programs late (Rogers, 2003). Informational and access advantages beget later advantages. **In** this way, evidence-practice gaps affect people and organizations differentially. Gaps are more pronounced for some than for others, contributing to social and economic disparities that harden inequality in America and elsewhere (Carter-Pokras & Baquet, 2002). Design research is being developed, tested, refined, and written about at a few, relatively elite institutions. Will educational researchers at lower tier and less wealthy institutions adopt design research as a methodology late relative to educational researchers at more elite institutions? We expect so, on the basis of prior studies of diffusion.

Purposive Diffusion of Design Research

Traditionally, the studies that comprise the diffusion of innovation paradigms have been descriptive or explanatory investigations created to answer questions of the sort:
To what extent did an innovation diffuse, and which variables account for this result? Diffusion does or does not occur; researchers assess what happened and why. This post

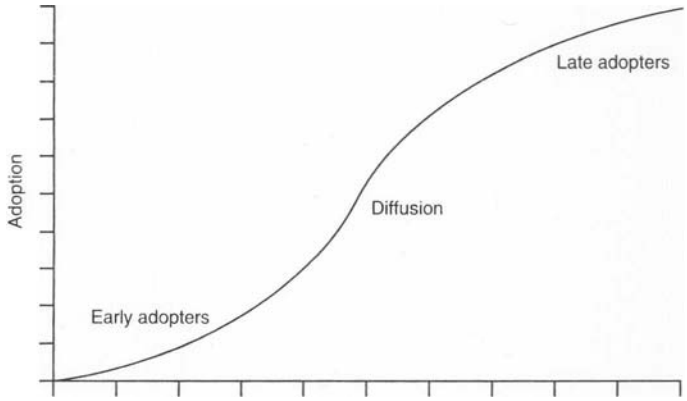

Figure 27.2 Innovations Spread Through a Social System or Social Sector After Positive Adoption Decisions and/or Social Modeling of the Innovation by Local, Informal, Opinion Leaders, Who Comprise a Subset of all Early Adopters.

hoc, postdictive orientation to the study of diffusion has aided the inductive reasoning that has led to our present understanding of the diffusion process.

To use what we know now to diffuse an innovation purposively is an interventionist form of predictive research. This type of research can be quite dissimilar to the traditional diffusion study. Yet, it is not new. Purposive diffusion has been conducted successfully for several decades, beginning with the purposive diffusion of birth control in the 1960s (Retherford & Palmore, 1983). Rogers (1973) presented a strategy for accelerating diffusion based on empirical studies of contraceptive adoption. Scholars used successfully diffusion concepts such as opinion leadership in field studies and computer simulations (Abrahamson & Rosenkepf, 1997; Freedman & Takeshita, 1969; Kelly et aI., 1997, 1992, 1991; Lomas et aI., 1991; Palmore, 1967; Valente & Davis, 1999). Predictive studies using diffusion attributes have been carried out by marketing scholars for years, based on the work of Frank Bass (1969) and by him and his colleagues (Bass et aI., 1994,2000). Tools have been developed for the objective of using diffusion principles (Dearing & Meyer, 1994). Most purposive diffusion interventions have only operationalized one diffusion principle only, such as opinion leadership or the attributes of innovations.

A purposive diffusion strategy that integrates and applies multiple validated principles is the most logical way to proceed with developing as intervention because, for anyone innovation type or for anyone set of potential adopters, a particular principle may be especially effective or ineffective, and the enactment of multiple validated principles may function additively to propel adoption decisions. Such a strategy means identifying and using multiple diffusion principles, each of which is well validated through empirical study, implementing them in concert, and collecting outcome data to summarize the effects and to process the data to indicate causes. Several authors have emphasized this potential of purposive diffusion (Anderson & Jay, 1985; Berwick, 2003; Dearing, 2004, 2005; Lenfant, 2003).

Here, we pose several questions for those involved in creating and refining design research. Our intent is to encourage consideration at this early stage of what will become important later if purposive diffusion is used to accelerate the spread of design research as a new and effective methodology for use among educational researchers and teachers.

Educational Problem that Design Research Addresses of Sufficient Importance to Warrant a Purposive Diffusion Intervention?

If we are to engage in intervention research, we have an obligation to be reasonably certain that the time and attention devoted to the effort is justified, given the costs of not being able to address other, worthy, scholarly topics and applied problems. Tied in to questions of importance is the need of potential adopters. Earlier, we indicated that adoption is tied to the compatibility of an innovation to the potential adopters' values, past experiences, and needs. If adopters do not perceive a need for an innovation, or if they perceive a lack of need by the larger community-including other faculty, K-12 educators, and the funding community-they are unlikely to adopt it. Is design research needed? By whom? And how do we know it is needed?

Is Design Research Ready for Purposive Diffusion?

An analysis of design research using innovation attributes suggests that the innovation is in a prediffusion stage and not ready for widespread diffusion yet. Most appropriate at this time are continued experimental demonstrations, perhaps including selected early adopters who can question aspects of implementation and, along with research teams, suggest modifications that may make adoption more likely. Attempts to diffuse an innovation purposively in a formative stage are likely to increase operational and evaluative uncertainty. If uncertainty leads to negative opinions, it will make the diffusion of design research at a later time even more challenging.

Is the Evidence About the Effectiveness and Efficiency of Design Research Sufficiently Convincing that this Approach to Educational Research and Practice Could be Diffused?

When we have a choice of what to propel into broader use, there is a responsibility to focus on those innovations that have been shown to be most effective and efficient. Effectiveness concerns the internal validity of the design research itself as it is enacted in classrooms: Does it work better than alternatives for research and pedagogical purposes? Efficiency concerns the cost of the innovation in classrooms. Is improvement achieved at advantageous or reasonable cost? This question is central to evaluative uncertainty.

Who are the Potential Adopters of Design Research, and do They Comprise a Social Network or Social Sector for Accessibility?

Educational researchers and communication among them most likely comprise multiple, overlapping, interorganizational, informal networks (invisible colleges) that may be stratified by variables such as institutional prestige, geography, and orientation to practice. Which of these networks should be targeted for the diffusion of design research? The answer(s} to this question can be provided by considering whether the educational researchers in question are accessible in a ready means such as through a professional society or through their ongoing interaction. Information about the existence of a social network (shared interpersonal ties) or shared information sources of people in a social sector (no shared interpersonal ties) is gathered most reliably and validly through the formative administration of questionnaires to network or sector members.

If potential adopters do not communicate already, they do not comprise a social or professional network. Such a set of potential adopters can be considered a soci:ll sector; they share common interests, attend to common sources of information, and have common responsibilities. What they do not share is direct and indirect interpersonal communication. When targeting a social sector for the purposive diffusion of design research, the question is how to reach the potential adopters with social influence messages (e.g., Mathematics Association of America sections or American Educational Research Association sections could be used as points of message dissemination) withoul an interpersonal communication network in place.

When a set of potential adopters constitutes a social network, the task is to conduct formative research to understand the influence structure among the units in the network. Questions designed to determine degree of influence have been posed to probe popularity, advice-giving, communication frequency, as well as asking more directly about influence. These variables arc highly correlated. Data about the distribution of influence in a network of educational researchers or teachers could he collected through sociometric roster questionnaires, in which each respondent is given a list of all the other respondents and asked to assign a score for such variables as how often the respondent talks with each person listed and what the nature of those conversations is; open-ended questionnaire items, in which respondents are asked to write in the name of, or an identifier for, those persons or units with whom the respondent communicates; informants, who are asked typically in interviews which others they consider to be most influential; or observation, in cases where the network of people is present in one location and small enough to observe through their interaction and be coded hy the observer. The resulting data, analyzed with social network analysis software, identifies which persons are most influential (the opinion leaders) for the given topic. This result is used formatively to contact the opinion leaders and recruit them to assist hy learning about the innovations in question and hy talking about the innovations with their followers.

Does the Targeted Population Constitute a Socially Responsible Choice?

Left to itself, diffusion often exacerbates societal, economic, and educational inequalities. In passive diffusion processes, early adopters are often the least likely to need the innovation in question but most likely to have the necessary resources to adopt it. Purposive diffusion can turn this around so that we focus on those most in need. For design research approaches, this could mean a focus on researchers who attend to classrooms with high proportions of population groups who are underrepresented in science and mathematics education, including women, ethnic minorities, and lowincome students. Such a focus embedded in a purposive strategy has the potential to prompt those educational researchers and practitioners who would be late adopters otherwise into trying design research early, relative to others (see Figure 27.3), and thus accrue the benefits thereof.

Can a Cluster of Innovations be Presented to Potential Adopters?

We postulate a curvilinear relationship between the degree of innovation choice and the likelihood of adoption. When a single innovation is communicated to potential adopters, a negative reaction is likely because of a loss of control born from a lack of choice (Brehm & Brehm, 1981). Given too much choice, potential adopters focus on the costs of adoption instead of considering the benefits (Schwartz, 2004). Offering a delimited choice of effective design research alternatives to potential adopting teachers

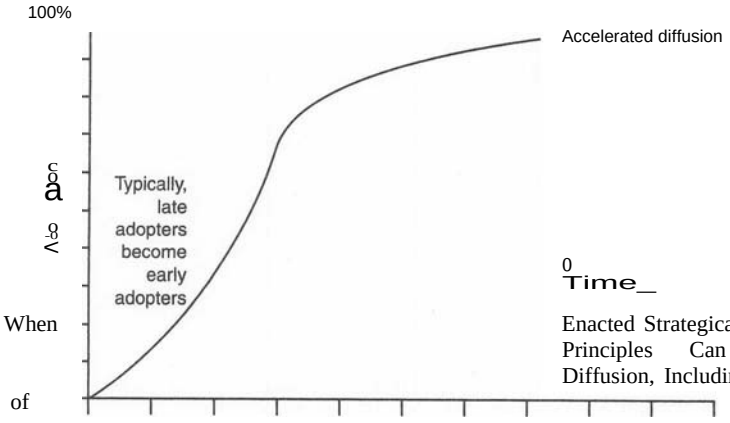

Figure 27.3 When Enacted Strategically, Diffusion Principles Can Accelerate Diffusion, Including the Spread of Effective Innovations Among Typically Disadvantaged Late Adopters.

or researchers heightens the likelihood that they may find an ideal fit between their local circumstances and research and/or teaching needs, on the one hand, and among effective practices in a cluster of design research innovations, on the other.

Clustering can increase both the likelihood of a positive adoption decision being made and of that choice being a most appropriate selection. When graphed over time, adopters of a particular innovation sometimes also adopt other related innovations at about the same time. Clustering has been shown to occur for recycling behavior (Leonard-Barton & Rogers, 1980), consumer information services (LaRose & Atkin, 1992), technologies at the organizational level in the United States (LaRose & Hoag, 1996), ideas, values, and tools at the individual level in Kenya and among Italian and Jewish women in the United States (Rutenberg & Watkins, 1997; Watkins & Danzi, 1994), as well as for other types of innovation.

This body of research concerns a complementary clustering effect, of one positive adoption decision seemingly precipitating several like decisions. Here, we extend the concept of clustering to include "alternative" clusters. An alternative cluster is a set of effective innovations that comprise different means to achieve the same end. For example, a cluster of several proven variants on design research methods, or a cluster of effective educational research methods one of which is design research, can be created and communicated. Piecing together an alternative cluster of effective innovations does not put a sponsor or change agency in the uncomfortable position of promoting one method over another and running the risk of seemingly advocating one intervention or one set of interacting innovations at the expense of solutions developed by others. Rather, potential adopters can choose from among a set, each of which addresses the same problem. Also, an alternative cluster allows potential adopters to engage in direct comparison of effective alternatives in the cluster using common metrics, developed or influenced by the researcher.

Can Design Research be Directed to Intermediaries so that the Broadest Possible Diffusion Effect May Occur?

Intermediaries, when targeted as adopters, in turn create, adopt, and adapt programs for others, such as educators who adopt innovations so that benefits accrue to their

students. This approach to social change has been referred to as "intervening upstream" (Singhal & Rogers, 2003: 17]). Professional associations (Newell & Swan, 1995), interorganizational networks, and organized centers for teaching excellence on campuses can be fruitful for the identification of potential adopters and their opinion leaders if the formative administration of questionnaires is not conducted to identify sociometrically local, informal, opinion leaders.

Can Design Research Portrayals (the Content and Format of Communication Messages Such as Web-Based, Decision Support Tools) be Developed on the Basis of What We Know About How an Innovation's Attributes are Perceived?

Formative research about how representative potential adopters perceive design research innovations is crucial to develop portrayals that elicit the informational, attitudinal, and behavioral responses that lead to positive adoption decisions. Research into attributes has been conducted to explain adoption decisions and, especially, consumer perception and purchase intention (Agarwal & Prasad, 1997; Manning et al., 1995). Clearly, the potential of the concept of attributes is in its application before diffusion (Rogers, 2003), either as a tool to assess likely reaction on the basis of representative sets of potential adopters during a formative pretesting stage (Dearing & Meyer, 1994) or as a basis for predicting diffusion (Tornatzky & Klein, 1982).

Portrayals of design research with the purpose of informing website visitors about what design research is and how it operates can be assessed for comprehension and perceptions of relative advantage, compatibility, complexity, testability, and observability, then refined. Currently, design research is high in operational uncertainty. When, over time, such uncertainty is reduced and standards are developed, diffusion attributes will provide a well-established framework to use in presenting design research to potential adopters.

Websites are promising media for presenting clusters of innovations because they can be designed to allow for direct comparison among innovations and evaluation under conditions of uncertainty (Hibbard et al., 2002; Tversky & Kahneman, 1982). Testimonials and examples of the innovation in action can be embedded in the site. Websites also are promising media for clarifying to potential adopters the evidence supporting each approach to design research, the causal model that is responsible for the observed effect of using design research and that should not be modified at least in its general terms by adopters, the peripheral components that may have contributed to external validity at second-generation sites, and those complementary assets and capacities at school or work that were present in cases of successful implementation. The objective of such portrayals is to give adopters the information necessary to understand how an innovation and their situation could be made to work well together-what scholars have referred to as a mutual adaptation perspective on implementing an innovation (Fishman et al., 2004; Leonard-Barton, 1988).

Our hope is that answers to these questions can prompt the preliminary exploration of whether to proceed with the purposive diffusion of design research and, if so, how to do it. We submit that the diffusion principles of innovation attributes, social influence, uncertainty reduction through demonstration, and clustering remain the same for design research as they do for many other innovations. What should differ will be the ways in which the principles operate in an intervention.

Note

1 According to the estimate of Everett M. Rogers (2003), the main chronicler of diffusion of innovation studies, there have been over 400 publications about the diffusion of educational innovations since the 1960s.

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