# Prevention through Design: Use of the Diffusion of Innovation Model to Predict Adoption

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## Abstract:

The Diffusion of the Innovation Model has been widely used to study the adoption of new innovations in many industries. The use of this model can provide valuable insight into the diffusion of Prevention through Design (PtD) health and safety technologies within the construction industry. This paper reviews the Diffusion of Innovation (DOI) literature; its applications for construction; and, specifically, for Prevention through Design (PtD) adoption within the construction industry. The importance of technology champions is reviewed. Technology champions can be used to aid in the adoption of PtD technology. However, the false identification of technology champions for PtD innovations can lead to the misuse or disuse of controls that have been developed. This paper examines the criteria that exist for the identification of champions and asserts that safety and technology championship are both critical elements of adoption of prevention through design innovations.



**Key Words:** Diffusion, Technology, Adoption, Prevention, Safety, Intervention


## 1. Introduction

Diffusion of innovation is the process through which an innovation, whether an idea or product, is communicated over a period of time in a social system and involves some degree of uncertainty (Rogers, 2003). Innovation is defined as a significant improvement in a product, process or system that is actually used and which is new to those who will be developing or using it (Manseau and Shields, 2005). One of the necessary components of an innovation is the ability of the innovation to improve some aspect of the adopter's performance of a work task (Toole, 1998). Two important factors that are involved in the diffusion of innovation are the discovery of the innovation and the diffusion of it (Ball, 1999). Diffusion involves communication about the innovation to the target adopters (Koebel, 1999). The Four main elements compose the general diffusion model as outlined in Rodgers 5$^{th}$ Edition of Diffusion of Innovations (2003) include: the innovation, communication channels, time, and a social system.

An **innovation** can be any idea, product, process or object that is perceived as new to an individual or group (Rogers, 2003). Innovation can take many forms and can be incremental, in which small changes occur based on current experience, radical, where a breakthrough in science or technology provides a new change, or modular, where there is a change in concept within a component of a larger system (Blayse, 2004). For a product, process or idea to be considered an innovation, it does not need to be something new pertaining to the time when it was created, but rather the newness of the innovation can be measured if it is new to the individual or adopting unit. The newness of an innovation

is often gauged on a person's knowledge, or decision to adopt (Rogers, 2003). The characteristics of innovation that are the most responsible for influencing adoption are:

a. Relative advantage- Relative advantage is perception that the innovation is better than the idea, product or process that already is in use by the potential adopter. If a potential adopter can readily see the benefits of using an innovation there is greater likelihood for adoption. The greater degree the adopter perceives the advantage, the more likely they are to adopt.
b. Compatability- Compatability is the degree to which an innovation is perceived as being consistent with the needs of the potential adopters. Adopters are looking for products they can incorporate into their systems without much effort and without having to change values.
c. Complexity- Complexity is the degree to which the potential adopter views the innovation in terms of how difficult the innovation is to understand or the ease of use of the innovation. If an innovation is easy to understand and use then the likelihood of adoption increases.
d. Triability- Triability of an innovation is the opportunity given to use an innovation on a trial basis before wholly committing to adoption.
e. Observability- Observability is the visible results of the innovation in practice. If observers can readily see the results of an innovation, the likelihood of adoption increases. (Rogers, 2003)

These five characteristics should be considered in Prevention through Design (PtD) innovations because they can aid in adoption. If aspects of these elements are not met, the missing pieces could represent barriers to adoption of innovation.

**Communication** is the second main element of diffusion. Diffusion of innovations is facilitated by tapping into many sources of communication and information (Toole, 1998). The process of communication through diffusion includes the innovation, an individual or group that has experience using the innovation or a knowledge of the innovation, an individual or group who does not yet know about the innovation or has not experienced it, and a way for these two parties to communicate with each other (Rogers, 2003). Many methods of communication are available for use in the diffusion process including the use of mass media, inter-organizational networks, educational institutes, research institutions, and professional associations (Sexton, 2004). Different kinds of communication channels have differing effects on the diffusion process and rate of adoption. Mass media provides an efficient channel for communication while interpersonal interactions remain the most important channel for providing information about innovations and influencing the adoption process (Lin, 1975, Rogers, 2003).

**Time** is a third element of diffusion of innovations. Time is a variable that is used to measure the rate of diffusion of an innovation and is one of the strengths of the diffusion of innovation model. Time is involved in diffusion in three major functions. The first is in measuring the time that passes from the time knowledge of an innovation is introduced to an individual or group and the time they adopt or reject the innovation. The second function time is the time in which an innovation is adopted by an individual or group in

relation to the introduction of the innovation into society. For example a person can adopt in the early introduction stages of an innovation or can wait and become a late adopter after seeing others adopt the innovation and use it successfully. A common element of the Diffusion of Innovation model is the graph of Everett Rogers for Technology Adoption Lifecycle that shows the distribution of adoption in relation to time shown in Figure 1. The third function of time in the innovation process is the rate of adoption that reflects the number of members in a system that adopt the innovation in a given time period (Rogers, 2003).

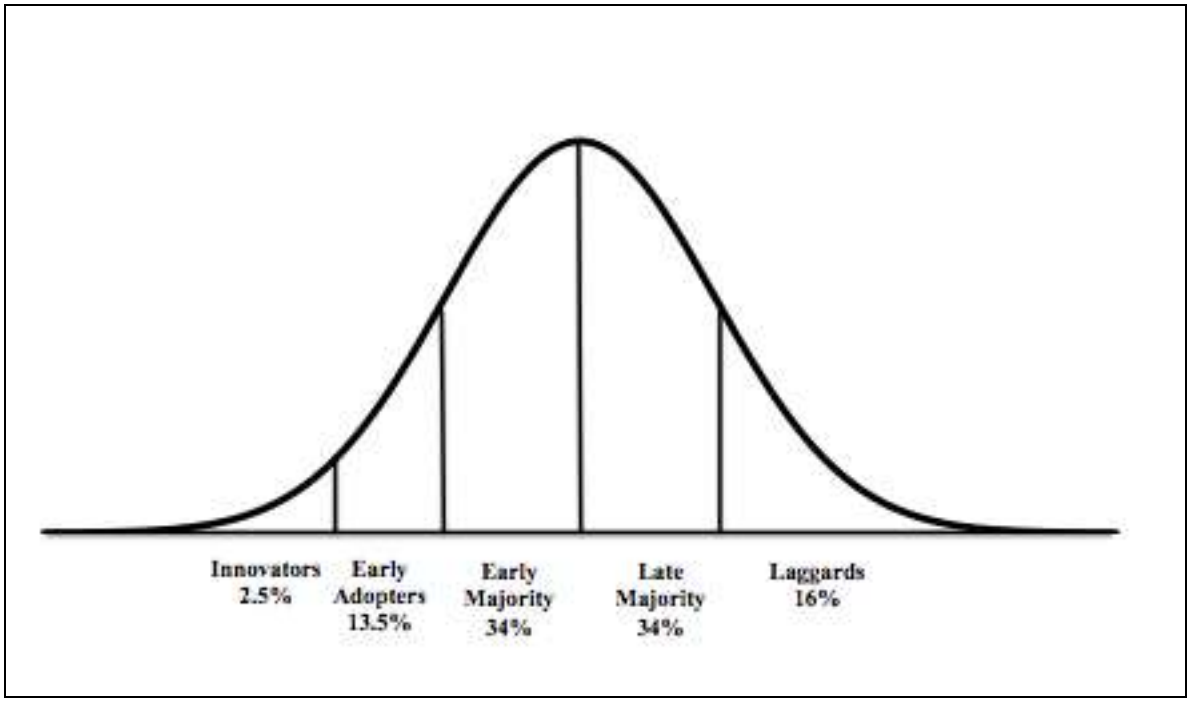


**Figure 1:** Bell Shaped Graph Depicting Levels of adopters (Rogers, 2003)

**Social systems** are the fourth element of diffusion of innovations. Social systems could be individuals, groups or members of organizations. The social system affects the diffusion of an innovation depending on the social system structure, processes, roles of members, types of innovation decisions and the consequences of adoption (Rogers, 2003). Innovative individuals known as opinion leaders or change agents are able to influence other individuals' attitudes and behaviors (Rogers, 2003). These opinion leaders also often referred to in innovation discussions as champions can come from formal leaders or informal leaders in a social system (Howell and Higgins, 1990, Markham, 2001). Social systems can also influence the adoption of innovation by deciding to adopt innovations by collective or authoritative decisions. Decisions to adopt innovations in a social system may be optional decisions that are left up to an individual, or collective decisions, which the decision to adopt or reject innovations is based on the consensus of the group. Social systems might also affect the adoption of innovations through the use of authority innovation decisions in which the decision for adoption lies with a few individuals who possess power. The fastest rate of adoption comes from authoritative decisions (Rogers, 2003).

**Diffusion in Construction**

Innovation in construction offers potential for significant company, social and industry benefits (Slaughter, 1998). The construction industry has been viewed as an industry that is resistant to technology and slow to adopt new innovations (Koebel, 1999). Innovation occurs in construction more than what is recognized by those outside the construction industry. A lot of the innovations done in construction are done by people working on site as opposed to large manufacturers (Slaughter, 1993). The importance of PtD innovation in the construction industry is recognized as a means to improving the quality of life, productivity and safety (Arditi et al., 1997). The amount of information presented to the potential adopter can greatly influence the decision to adopt. Innovations can be categorized into high uncertainty and low uncertainty innovations. High uncertainty innovations are those in which potential adopters are missing substantial information relating to for example, long-term performance, total installed cost, safety, and acceptance by customers. Low uncertainty innovations are those which potential adopters are missing relatively little information pertaining to these criteria (Toole, 1998).

Much of the research on innovation in the construction industry has focused on the barriers in the industry (Slaughter, 1993). Adoption of innovations in construction are defined as occurring when a firm uses a technological innovation in at least 25% of the cases in which it has an opportunity to use it (Slaughter, 1993). Frequent downturns in the construction market may deter firms from adopting innovations (Blackley and Shepard, 1996). Regulatory bodies in construction can also have an impact on the successfulness of innovations. The development of new products or processes in construction is not always be welcomed by all parties (Oster, 1977). Stringent standards for product performance, safety and environmental impacts can create pressure for firms to innovate improve quality and upgrade technologies (Gann et al., 1998). Unions may resist innovations that are viewed as labor saving or eliminating products or processes (Blackley and Shepard, 1996).

Cost, risks, uncertainty and control over limited aspects of the way that construction work is performed and the products that are chosen makes diffusion of PtD innovations in the construction industry difficult (Manseau and Shields, 2005). Barriers that affect the implementation of innovations also include forms of contracts, the cost of research, lack of information about the innovation or being unaware that one exists and not realizing the potential cost savings of adoption (Ling, 2003). Many of those in the construction industry are looking for proof that products and processes will provide an advantage over existing methods and products (Toole, 1998). Builders are frequently unwilling to adopt innovations because of the risks that fall on the builder without capturing the benefits (Manseau and Shields, 2005).

One significant barrier to adoption for PtD methods in the construction industry is that there is a lack of belief among the users that a hazard actually exists or they lack the confidence that they are able to control the hazard (Kramer et al., 2009). The lack of understanding that hazards exist or that controls are available can influence the decisions

of managers. Managers tend to devote more attention to items that are failing than items that are meeting their targets (Mitropoulos and Tatum, 1999). If a manger doesn't perceive there is a problem then they are unlikely to adopt innovations.

## 2. Using Diffusion Theory to Understand the Adoption-Use of New PtD Technologies in Construction.

The use of the diffusion model can help in understanding the adoption use of new PtD technologies in construction. Using the diffusion model as a guide and focusing on the four elements of the diffusion model, researchers can determine the most effective ways to increase diffusion of PtD innovation in the construction industry. A review of the four elements of the model as it pertains to PtD innovation diffusion in construction companies will be outlined to help understand the barriers that exist to increased use of new PtD safety technologies in construction.

### The Innovation

The four elements of the diffusion model can be used to examine the understanding of adoption. The five characteristics of an innovation are important determinants in the decision to adopt PtD technologies in construction.

1. Relative Advantage- The use of PtD technologies must provide the potential adopter with the perception that the use of the technology is better that the current method of doing work. This relative advantage could be described as having a greater advantage in terms of cost, production or safety. An innovation must allow the adopter to execute actions that increase the organization's performance (Toole, 1998). Construction firms tend to innovate when there is a clear potential for increased profits (Utterback, 1974).

2. Compatability- The use of PtD technologies needs to be presented to the adopter as consistent with the desired outcomes that current methods produce. Some innovations can disrupt the working system which could result in delays or reduced quality creating additional costs (Toole, 1998). Technologies which construction companies tend to adopt are those that can contribute to the business quickly with visible results (Sexton, 2004).

3. Complexity- The PtD safety innovations needs to be easy for the user to understand and the tools need to be easy to use to increase the likelihood of adoption. New technologies acceptance is helped by the availability of properly trained and skilled people (Arditi et al., 1997).

4. Triability- Letting companies have hands-on experience using the PtD method prior to adoption will allow for a risk free trial and improve self-efficacy in the use of the innovation and will increase the likelihood of adoption. Builders responses to innovations are considerably different when presented the

opportunity to view and touch the product (Toole, 1998). A high degree of user involvement is needed in the construction industry innovation process (Manseau and Shields, 2005).

5. Observability- The innovation needs to be presented in a way that the results of using the innovation are observable to others. PtD innovations can benefit multiple trades on site and will be visible to others who will encourage adoption. Innovators have their eye on advantageous innovations and ones that are easy to implement (Manseau and Shields, 2005).

**Communication**

Communication channels can be used in the construction industry to increase adoption of PtD innovations. Construction safety innovations including PtD innovations face obstacles due to the limited knowledge of the innovation and the benefits it may provide (Nooteboom, 1994). Potential adopters of innovations in construction are missing a tremendous amount of information (Toole, 1998). In the diffusion model, communication is distributed in different ways. Information concerning the benefits of the usage of PtD innovations could be achieved through training and re-training courses, as well as training manuals or distributed informational materials (Gherardi, 2000). Diffusion of innovation can not be achieved unless others transfer knowledge and diffuse information about innovations to others (Peansupap, 2005). Knowledge and competence are key elements that influence the personal safety performance of construction workers (Langford, 2000).

**Time**

Time is used in the diffusion model to understand the rate of adoption of innovations. The time an innovation is introduced to the time it is adopted can be the result of how ready to adopt the firms may be (Rogers, 2003). Construction innovations tend to face obstacles that delay the diffusion of innovation due to liability, regulatory codes and the lack of information (Manseau and Shields, 2005). When presented with innovations, people may expect that something better will come along shortly so they wait and watch the experience of others before adopting which is a retarding factor in the time element of diffusion (Ball, 1999). The relative newness of a PtD innovation may have an effect on the adoption rate among construction companies. As time goes on and information increases diffusion is expected to increase.

**Social System**

Diffusion of innovation in construction firms requires addressing the social system of the industry. The norms of a social system are the established patterns of behavior for the members of the system. Norms set the standard and relate to individuals what behavior is expected (Rogers, 2003). Introducing changes into a construction social system can create ripple effects that can be difficult to anticipate (Manseau and Shields, 2005). The culture of a company can play an important role in the adoption of innovations within a

social system and innovations should try to be compatible with the normal behaviors that are in place. Structural barriers such as building codes, and construction safety and health regulations can constrain or drive innovations. Safety and environmental factors can apply pressures for firms to adopt innovations or upgrade technology (Manseau and Shields, 2005). The use of safety and health information dissemination and the enforcement of regulations is an effective way to increase PtD innovation adoption among construction companies as well as other innovations in the construction industry that increase worker safety and health. The use of regulations creates an administrative innovation decision where the decision is made by those with authority and takes away the optional innovation decision of the individual (Rogers, 2003).

Another import aspect of the social system element of diffusion of innovation that can be used to help in the adoption is the use of technology champions to influence other individuals' attitudes towards adoption. Interventions have often used a champions to provide education, champion a product, or to give support for the innovation. Reviews of interventions using champions have been found to be moderately successful (Thompson, 2006). The use of champions could be beneficial in the diffusion of PtD technology usage by using persuasive people to increase the recognition of the innovation and share experiences. Champions provide a transfer of knowledge at an interpersonal level that plays an important part in adoption (Koebel, 2008)

Using the four elements of the diffusion model, the innovation, communication, time and social systems as a guide can influence the adoption of new PtD innovations in construction. It is recommended that the elements discussed herein be considered and incorporated into the design of an PtD interventions to increase diffusion of innovation in the construction industry.

**Technology Champions**

Frequently the term technology or innovation champion is used to label an individual who is a leader in the innovation process (Nam and Tatum, 1997). There are many terms in diffusion research for an individual who acts as a champion, champions are also called opinion leaders, facilitators, linkage agents or change agents (Rogers, 2003, Thompson, 2006). Research has found that about 70% of construction firms have technology champions who keep others in the company aware of new products and processes. The role of champions varies between small and large firms (Koebel, 2008). Champions are individuals who influence innovation in their organizations or areas of influence (Lin, 1975). The role of a technology champion is to drive innovation and be able to absorb the risk of adopting innovations. A technology champion can be delegated only if the person has slack resources and enough power to implement innovations (Ling, 2003).

Champions need to have past experience and resources as in time or money (Nam and Tatum, 1997). Champions act as gatekeepers of knowledge who help transfer knowledge and diffuse innovations to others (Lin, 1975). Champions aren't usually assigned and can be formal leaders with titles and positions or informal leaders who others look to for information (Howell and Higgins, 1990). Technology champions feel that using

interpersonal relationships is a key to influencing innovation and understand that diffusion is a social process (Thompson, 2006). Studies of product innovation success have shown that champions are influential in overcoming barriers to adoption within organizations. Champions who promote innovation can influence the organization to learn about new niches and to develop new processes by fostering communication within firms and stimulating managers to make decisions about innovation (Howell et al., 2005).

**Identifying Innovation Champions**

Based on a review of literature, many identifying factors are exhibited by technology champions. Some of the identifying factors of champions as found in the literature are:

- Highly enthusiastic people who are willing to make special efforts and take risks to implement innovations, and individuals who have slack resources. (Nam and Tatum, 1997).
- A champion is someone who is open to new ideas (Kramer et al., 2009)
- Champions need to have: a technical competence and understanding of how the innovation works, a knowledge of the company so they can identify relevant ideas, a knowledge of the market, a personal drive to push the idea ahead and get decisions made, and a champion needs to get along with different people and communicate well (Chakrabarti, 1974)
- Champions are persistent even in the face of obstacles. They exhibit self confidence in their own ideas and are highly motivated to influence their followers (Howell and Higgins, 1990)
- Champions are persuasive and willing to take calculated risks and adopt products as their own to promote them. Personal ownership of an idea is a critical quality of a champion (Thompson, 2006)
- Technology champions are indispensible sponsors, protectors, and promoters of innovations who are able to negotiate and balance the opportunities of new approaches with the risks of departing from the tried and tested (Manseau and Shields, 2005).

A champion is an individual who recognizes a new technology as having a significant potential, adopts the project as their own, commits to the project, and seeks to generate support from other people in the organization. A champion can arise from any level of an organization, they get resources to keep the innovation alive, they support projects when there is potential to benefit the champion's own department and are just as likely to promote innovation that are failures as they are to promote successful innovations.

Identifying a champion can be difficult but similar qualities exist in the various definitions of champions. People who are enthusiastic, committed people who are willing to take risks to implement innovations should be sought out as champions. A person may view themselves as a champion but a good way to identify a champion is through peers and senior managers (Howell et al., 2005, Thompson, 2006). These qualities can be used as good indicators to identify existing champions for new PtD technologies in the construction industry as well as promoting new champions in the intervention process.

## False Champions of PtD Innovation

It is essential to ensure that observed behavior is truly indicative of technology champion-ship and not some other construct. Management commitment is a strong indicator of the success of any safety intervention. If manager is not a true champion for a safety innovation, then the likelihood of the intervention having and impact on worker safety is diminished because workers can see that safety is not important to the management's goals (Marsh et al., 1998). There is a natural tendency for a champion to want to select out the desirable parts of an innovation to adopt and to reject the rest. This is often caused by a lack of efficacy of certain elements of an innovation, personal preferences of champions or strong organizational norms (Bresnen, 2001). An unbalanced pursuit of purpose shows how in business situations driven by profit and production, destructive behavior can actually be incentivized. Decision making of champions can be motivated by market approval, government regulations, and safety threats that are ethically inadequate since some organizations never take the time to look at the overall purposes of their chosen practices (Goodpaster, 2000). The problem with falsely identifying a innovation champion for a PtD innovation is that the champion might champion the wrong behavior and the intervention may lose its original meaning and the impact might be lessened (Bresnen, 2001).

Interventions should be aimed at introducing PtD innovations to prevent future potential injury and illness among workers. Preventative safety innovations have been perceived as having low relative advantage as compared to other innovations that are designed to create a profit (Rogers, 2002). Perceived relative advantage has been found to be the most important predictor of the rate of diffusion causing preventative innovations to be slowly adopted. Increasing the rate of preventative innovation adoption can be helped by increasing the perceived relative advantage (Rogers, 2003). If safety prevention is the only perceived relative advantage then the innovation will be unlikely to be adopted (Rogers, 2002). The encouragement of true champions in PtD interventions will to help diffuse information through social networks.

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