
AC 2011-303: BRIDGING THE VALLEY OF DEATH: A 360 APPROACH TO UNDERSTANDING ADOPTION OF INNOVATIONS IN ENGINEERING EDUCATION

Kirsten A. Davis, Boise State University

Kirsten A. Davis is an Assistant Professor in the Construction Management Department within the College of Engineering at Boise State University. Dr. Davis earned a B.Arch. in Architecture and a B.S. in Civil Engineering from the University of Tennessee, an M.S. in Civil Engineering specializing in Construction Engineering and Management from the University of Colorado, Boulder, and a Ph.D. in Civil Engineering specializing in Construction Engineering and Management from Virginia Polytechnic Institute and State University. Her educational research interests are focused on improving construction management education.

Sondra M Miller, Boise State University

Ross A. Perkins, Boise State University

Dr. Perkins teaches course in instructional design, evaluation, and international perspectives in BSU's Department of Educational Technology, where he has been an assistant professor since 2008. His research interests include STEM education, diffusion of innovation studies, and distance learning. Perkins received his doctorate in instructional systems design at Virginia Tech.

Bridging the Valley of Death: A 360° Approach to Understanding Adoption of Innovations in Engineering Education

Abstract

There is a nationwide need to better translate engineering education research into the classroom setting. Moving engineering education research into practice is a more complicated task than it might initially seem. There are many significant barriers to hinder the transition from research to implementation. These barriers can be categorized into two groups: (1) individual barriers, such as personality characteristics that contribute to a lack of willingness to implement innovations, as well as a lack of knowledge about engineering education research; and (2) environmental perceptions, such as perceptions of the tenure and promotion that suggest a lack of support for innovations.

The project discussed in this paper investigates the characteristics of faculty members who successfully adopt engineering education innovations and studies the impact of their working environment on their decision to adopt. Additionally, the project investigates characteristics of faculty members who do not adopt engineering education innovations and whether that decision was affected by perceptions of their working environment.

This paper describes the identification of current barriers to the adoption of innovations in engineering education using a 360° approach. Perspectives include that of self, colleagues, students, experts in education innovation (such as the director of a center for teaching and learning), and the reality (from administrators and published documents) and perceptions (from individuals) of the tenure process and rewards/incentives. This 360° approach provides a foundation for bridging the gap, often referred to as the ‘valley of death,’ between engineering education research and the common practice of engineering education.

Introduction

The act of translating research into practice is often a tenuous one, regardless of the context. Money and time are spent performing research, the results of which may be later abandoned or ignored instead of moving the knowledge (or product) gained forward into practice (or market). This chasm between research and practice where innovations disappear is sometimes referred to as the ‘valley of death’¹. It has also been described by some with a ‘survival of the fittest’ analogy². Regardless of the term used, the end result is the same – investments in research are made, but research often gets lost and never gets transferred to practice when the intermediary step is ignored.

This concept is true for product innovations – many products and inventions never evolve beyond the inventor’s desk, though many lack only funding to progress to that next step². This is equally true for engineering education innovations. Research in engineering education is supported through funding from organizations such as the National Science Foundation (NSF) and is published in journals such as the Journal of Engineering Education, yet research results are not often put into practice in engineering classrooms across the United States³.

Organizations such as the American Society for Engineering Education (ASEE) and the National Academy of Engineering (NAE) agree that we must produce engineers today and into the future with competencies well beyond those expected of past engineers, as well as prepare our new engineers to work in a global society^{4, 5}. Engineering education itself must change and become more effective and efficient to accomplish this feat⁵. We must draw on the available engineering education research to improve our classrooms and our teaching both now and into the future.

Moving engineering education research into practice is a more complicated task than it might initially seem. There are many significant barriers to hinder the transition from research to implementation. These barriers can be categorized into two categories: individual barriers and environmental perceptions. Some examples of these barriers are listed below.

- Individual barriers:
 - Personality characteristics contribute to an individual faculty member's desire and willingness to implement or ignore innovations in engineering education^{6, 7}.
 - Current and emerging faculty members are highly skilled in the technical aspects of their engineering specialty while pedagogy is often missing from their professional development^{6, 8}.
 - Many faculty members lack specific knowledge of current research in engineering education^{5, 6}.
- Environmental Perceptions:
 - Perceptions of the tenure and promotion system at many institutions suggest that changes in engineering education are not supported^{5, 6, 9}.
 - Faculty members perceive that rewards and incentives for implementing innovations in engineering education are not rewarded at the same level as advances in scholarly pursuits^{10, 11}.
 - Demands of faculty members to teach courses, conduct scholarly activity, and perform service contribute to a perceived lack of time to implement innovations in engineering education^{10, 12}.

There are also barriers at a level beyond individuals and their organizations, including the lack of funding for the intermediate step between research and practice and a lack of engineering education programs, particularly at the graduate level, promoting educational research and its value. There are currently only four such programs in the U.S.

To address these challenges, this research project investigates the characteristics of faculty members who successfully adopt engineering education innovations and studies the impact of their working environment on their decision to adopt. Additionally, the project investigates characteristics of faculty members who do not adopt engineering education innovations and whether that decision was affected by perceptions of their working environment. This work promotes successful faculty characteristics and work environments by recognizing aspects that are effective in the transition from research to practice. It also acknowledges faculty characteristics and perceptions of work environments that may impede the successful adoption of engineering education innovations into the classroom. This project promotes a realignment of individual and institutional priorities through the development of an implementation model aimed at increasing the number of faculty successfully adopting education innovations.

Objectives

The goal of this study is to promote successful faculty characteristics and work environments by recognizing aspects that are effective in the transition from research to practice. The project will develop new knowledge in the areas of adoption of innovations, change management, and attitude-behavior theory. Specific research objectives for this project include:

- Characterize faculty members who:
 - successfully implement engineering education innovations;
 - choose to not implement engineering education innovations;
- Characterize work environment perceptions of faculty members who:
 - do implement engineering education innovations;
 - do not implement engineering education innovations;
- Identify characteristics of:
 - successful engineering education innovation adopters;
 - work environments that promote and those that impede successful implementation of engineering education innovations by individual faculty members; and
- Develop an implementation model that promotes successful faculty characteristics and work environments.

Specific tasks, discussed in further detail in the Plan of Work, must be performed in order to achieve these research objectives, including:

- Assess, document, benchmark, and validate: a) characteristics of individuals who adopt (or choose not to adopt) engineering education innovations and b) their respective work environment;
- Analyze faculty characteristics of adopters and non-adopters to determine the correlation of faculty characteristics with successful adoption;
- Analyze the interactions between the work environment perceptions and individual faculty characteristics to identify relationships for model creation; and
- Develop and validate a new implementation model to enable more successful transfer of engineering education research to practice.

Plan of Work

This research project will categorize faculty members as adopters or non-adopters of engineering education innovation and will investigate the characteristics of those faculty members and the impact that perceptions of their working environment have on their decision whether or not to adopt. This information will be gathered through a combination of surveys, interviews, and focus groups. The data will be analyzed to identify characteristics of successful adopters. Important interactions from the work environment that promote or impede success of an individual will also be identified. An implementation model will then be developed to promote successful characteristics and work environments.

The research approach is comprised of three phases: (1) Assessment; (2) Analysis; and (3) Model Development. The first phase assesses, documents, benchmarks, and validates characteristics of individual faculty members who adopt (or choose not to adopt) engineering education innovations. This phase also assesses, documents, benchmarks, and validates perceived

characteristics of the respective faculty members' work environments. The second phase analyzes faculty member characteristics of adopters and non-adopters to determine which characteristics correlate with successful adoption. Interactions between the work environment perceptions and individual faculty characteristics will also be analyzed to identify relationships for model creation. The third phase of the project develops and validates a new implementation model to enable more successful transformation of engineering education research into practice. Each of the phases is described in more detail below.

Phase I: Assessment

Phase I addresses the first two objectives of the study, which are: (1) to characterize faculty members who successfully implement engineering education innovations, as well as those who choose not to; and (2) to characterize work environment perceptions of faculty members who adopt engineering education innovations, as well as those who do not adopt. Phase I consists of one task – data collection.

Task 1 – Data Collection. The first phase of this project involves extensive data collection. Data collection techniques include self-report surveys, focus groups, individual structured interviews, and document analysis. The data on this project will be collected using a 360-degree or multi-rater type of collection method. The 360-degree method is commonly used in performance evaluations, providing feedback to an individual from multiple perspectives¹³. This method will be used to collect data for this project from many different perspectives forming a reliable and valid picture of faculty member characteristics and their work environment perceptions. Perspectives include that of self, colleagues, students, experts in education innovation (such as the director of a center for teaching and learning), and the reality (from administrators and published documents) and perceptions (from individuals) of the tenure process and rewards/incentives (see Figure 1).

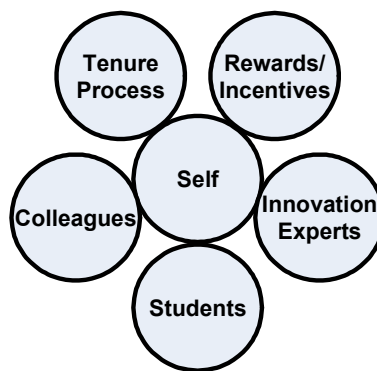


Figure 1. 360-degree data collection

While it would be desirable to sample engineering faculty throughout the U.S., the current project limits the scope to a single university and focuses instead on collecting data and analyzing the issues in greater depth instead. Future work should broaden the sample to numerous universities to account for environment perception issues that may be missed in this study due to the focus on a single university. The sample for this project will be faculty in the College of Engineering at Boise State University (BSU), a predominantly undergraduate university. The College of Engineering (COEN) has seven Master's degree programs and one

Ph.D. program, in addition to six undergraduate programs. There are approximately 70 tenured and tenure-track faculty members in COEN serving approximately 1,500 undergraduate and 300 graduate students.

Self-report surveys are one type of data collection method that will be used to characterize individual faculty members ('self' in Figure 1). Data collected will include a set of demographic questions such as age, gender, and level in the organization (e.g., instructor, assistant professor, etc.). Another set of questions will evaluate an individual's attitude towards change and will include metrics such as the Change Scale¹⁴, the Reaction-to-Change Inventory¹⁵, and the Irrational Belief Scale¹⁶. The Change Scale indicates that "individual differences in attitudes toward change may reflect differences in the capacity to adjust to change situations"¹⁴. The Reaction-to-Change Inventory measures an individual's perceptions about change¹⁵. The Irrational Belief Scale measures an individual's irrational ideas about change and their interpretations of how the change will occur¹⁶. These questions will enable us to evaluate the willingness a faculty member exhibits to use a new innovation. There will be additional sets of questions allowing individuals to self-evaluate their knowledge about pedagogy, engineering education innovations, and whether they use engineering education innovations in their classroom, as well as questions regarding their perceptions on the tenure process and the reward/incentive structure of their work environment.

Self-report surveys will also be used to gather data from colleagues. Data collected will include opinions/ratings regarding whether their colleagues use engineering education innovations in the classroom. These surveys will be randomly distributed, completely anonymous, and will be administered similar to an anonymous performance evaluation of a colleague or superior. The anonymity is important to avoid inflated ratings of colleagues. This data will validate the self-report data from faculty. It will also allow us to determine how much sharing of education research knowledge is actually occurring between faculty members. Our goal is to obtain information from nine to twelve colleagues of each faculty member as this will provide the greatest reliability and validity¹³.

Focus groups will be used to collect data from students and will concentrate on students enrolled in courses that are taught by faculty members who use (or claim to use) engineering education innovations in their classroom. This will provide an additional perspective on the reliability and validity of the self-report data from faculty. Depending on the students' perceptions of the successfulness of their professors, it may also provide a differing opinion of how useful engineering education innovations are, when compared with the literature.

Individual structured interviews will be used to provide the remaining data in the 360-degree review. Experts in education innovation (such as the director of a center for teaching and learning) will be interviewed to determine successful adopters of education innovations. Interviews will be conducted with the Dean and Associate Dean of Engineering, as well as the Provost, to learn how the tenure process and the reward/incentive structure within the College of Engineering, and at the University overall, are viewed by the administration. This is likely to provide a very different perspective than the perceptions of faculty members on their self-report surveys.

Lastly, document analysis will be used to examine the published information regarding the tenure process and the reward/incentive structure at the University. It is expected that the data gathered from the published documents will be different from the perceptions of individual faculty members, as well as differ from the information received in the interviews from administrators.

Phase II: Analysis

Phase II addresses the third objective of the study, which is (3) to identify characteristics of successful engineering education innovation adopters and to identify characteristics of work environments that promote individual success, as well as those that impede success. Phase II consists of two tasks – analysis of individuals and analysis of work environments.

Task 1 – Analysis of Individuals. This first task, the analysis of individuals, will use portions of the data collected in Phase I to identify characteristics of successful engineering education innovation adopters. To complete this task, we must first determine whether each individual faculty member is considered a successful adopter or not. We will evaluate each individual and rate them as an adopter or non-adopter, based on their knowledge of engineering education innovations and their self-evaluation of whether they adopt or not. Our evaluation will be based on data collected from the individuals themselves, as well as that collected from colleagues and students, and will also make use of expert opinions gathered from the Center for Teaching and Learning at BSU. Using a variety of data sources and involving experts greatly improves the reliability and validity of the analysis. It is important to note that the determination of adopter or non-adopter is based on a snapshot at a particular moment in time. It does not mean that the faculty member cannot change his or her status in the future. We have chosen the dichotomy of adopter/non-adopter purposefully, although there may be much debate on the stages or levels of adoption an individual may pass through. For the purpose of this research, adoption will be defined as those who have incorporated engineering education research into their classroom. All others will be considered non-adopters. This definition clearly defines success based on the end goal – to incorporate engineering education research into the classroom.

Once we have categorized the faculty members into adopters and non-adopters, we can then identify characteristics of the individuals that are indicators of success. Specifically, we are looking for characteristics that are unique to successful adopters. Both quantitative and qualitative data analysis methods will be used to identify these characteristics. Quantitative data analysis will be used to assess personality characteristics collected with the self-report survey, such as the metrics indicating an individual's attitude towards change that were described in Phase I. Qualitative data analysis will be used to assess faculty members' knowledge of pedagogy and current research in engineering education. In preparation for Phase III, Model Development, we will also rank individuals on their knowledge of engineering education innovations (from no knowledge to high knowledge) and on their willingness to adopt new innovations (from not willing to very willing).

While not truly characteristics, we would also like to analyze the data to determine whether any demographics of the individuals correlate with successful adoption. Questions we hope to answer from this portion of the study include:

- Does the gender of a faculty member have any correlation with knowledge of engineering education innovations, willingness to adopt those innovations, and/or successful adoption of innovations?
- Does the tenure status of a faculty member have any correlation with knowledge of engineering education innovations, willingness to adopt those innovations, and/or successful adoption of innovations?

Task 2 – Analysis of Work Environments. In this task, we will analyze the work environment using qualitative analysis. Specifically, we want to characterize perceptions of the work environment that are unique to successful adoptions of engineering education innovations, as well as characterize perceptions that impede adoptions. We will use the portions of the data collected in Phase I that focus on the reality and perceptions of the work environment as they relate to adoption of engineering education innovations. The reality of the work environment will be assessed based on the data gathered from the individual structured interviews of administrators and from the document analysis. Perceptions of the work environment will be gathered from individual faculty members' self-report surveys.

Questions we hope to answer from this portion of the study include:

- Based on faculty perceptions, what characteristics of the work environment promote adoption of engineering education innovations?
- Based on faculty perceptions, what characteristics of the work environment impede adoption of engineering education innovations?
- Is the reward/incentive system truly an influence on engineering education innovation adoption or is that only a perception?
- Is the tenure/promotion system truly an influence on engineering education innovation adoption or is that only a perception?
- Does the gender of a faculty member have any correlation with their perceptions of the influence of the work environment on their adoption of engineering education innovations?
- Does the tenure status of a faculty member have any correlation with their perceptions of the influence of the work environment on their adoption of engineering education innovations?

In preparation for Phase III, Model Development, we will also look at how perceptions of the work environment may influence an individual's knowledge of engineering education innovations and his or her willingness to adopt new innovations by answering the following questions:

- Does a faculty member's perception of the work environment influence their willingness to adopt engineering education innovations?
- Does a faculty member's perception of the work environment influence their knowledge about engineering education innovations?

Phase III: Model Development

Phase III addresses the final objective of the study, which is (4) to develop an implementation model promoting successful characteristics and work environments. Phase III consists of 2 tasks – development of the model and validation.

Task 1 – Model Development. The most widely recognized model of the diffusion process is Rogers’ diffusion of innovations model¹⁷. Diffusion here is defined as “the process by which an innovation is communicated through certain channels over time among the members of a social system”^{17, p. 5} and innovation is defined as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption”^{17, p. 11}.

Rogers’ model categorizes potential adopters of an innovation into five groups, based on innovativeness – the time at which an individual adopts an innovation. Figure 2 illustrates this model. Innovators represent the first 2.5% of adopters within a social system. Innovators are adventurous individuals willing to accept the uncertainty surrounding an innovation at the time of adoption. Early adopters represent the next 13.5% of individuals in the system adopting the innovation. Early adopters are respected individuals within the system that are generally thought to be role models for the group. This category includes a majority of the opinion leaders in the social system (those whose opinions are sought by others considering the adoption). The next 34% of adopters are known as the early majority and are sometimes described as the deliberators. Their decision process is longer than for the innovators or the early adopters, but they are very willing to adopt new innovations once they have learned enough to make the decision. The late majority (34%), on the other hand, adopt because of economic necessity or pressure from others within their social system. They are generally very skeptical about the innovation and wait until most of the uncertainty surrounding the innovation has vanished. The last group to adopt an innovation are the laggards, which represent the final 16% of adopters in the system. They tend to be suspicious of all aspects surrounding the change and are usually individuals at the perimeter of the system. They need to know that all of the uncertainty has been removed from the innovation. It is important for them to know that the innovation will definitely succeed. It is important to note that Figure 2 only accounts for adopters of the innovation. Non-adopters (those who never adopt) are not represented in this model.

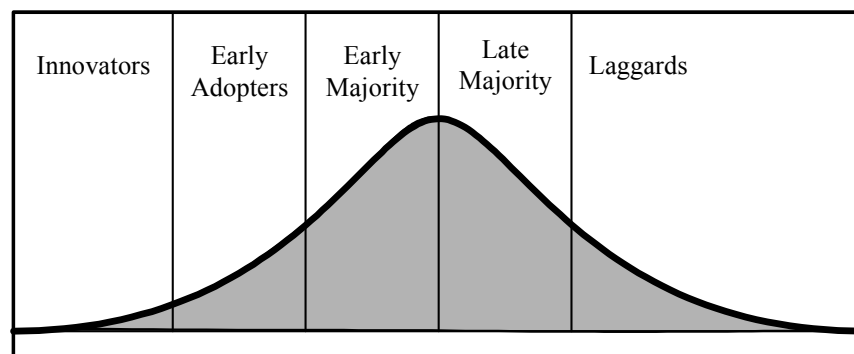


Figure 2. Rogers’ Adopter Categorization During the Adoption Process
adapted from ^{17, p. 262}

While sometimes understanding the timing of an individual adopting an innovation is important, for this project it is neither terribly useful, nor possible. Without a longitudinal study examining individuals and when they choose to adopt an innovation, timing of adoption is impossible to accurately measure. The more pressing issue is not when an individual adopts, but how to ensure that they do regardless of the timing.

With that in mind, this project will focus instead on the five stages individuals go through when considering adoption of an innovation, as well as the corresponding strategies to increase the likelihood of adoption (see Table 1)¹⁸.

Table 1. Stages of Adoption

Stage of Adoption	Recommended Strategy
1. Aware	Advertise
2. Curious	Inform
3. Envisions	Demonstrate
4. Tries Out	Train
5. Uses	Support

The aim of the project is to promote successful characteristics of individuals and their work environments that will encourage movement toward higher stages of adoption, with the ultimate goal of sustained use of education innovations in the classroom. The implementation model we propose is based on the Johari Window¹⁹. The Johari Window is typically used to document and improve self-awareness, as well as allow individuals to understand each other better within a group. It is focused on soft skills – what we commonly refer to today as Emotional Intelligence²⁰. Figure 3 shows a typical Johari Window model on the left and our proposed transformation into an implementation model promoting successful characteristics of faculty members is on the right. Our proposed model specifically looks at faculty characteristics with respect to knowledge about engineering education innovations and their personal willingness to adopt new innovations. By learning what their knowledge and willingness levels are, we can then identify their probable stage of adoption, represented by the six panels of the model. Knowing their stage of adoption, we can make specific recommendations on the strategy that should be used to encourage their movement towards adoption (see Table 1 above for recommended strategies).

Figure 4 shows examples of what the final model might look like. The left side of Figure 4 shows four example data points (points (a) through (d)) representing the characteristics of four faculty members with respect to their knowledge about engineering education innovations and their personal willingness to adopt new innovations. We expect our completed model to have data points in all six levels of adoption.

The right side of Figure 4 shows examples of the influence that environmental perceptions may have on the individual. While it is unlikely that environmental perceptions would cause a faculty member to have less knowledge about engineering education innovations (where the data point moves to the right), other permutations of influence are possible. For example, individual (a) shows characteristics that indicate high knowledge of engineering education innovations and

high willingness to adopt innovations and they are likely to actually use new innovations in their classroom. Yet when their perceptions about their work environment are included in the model, their willingness drops and they may not choose to use new innovations regularly. Individual (b) has little knowledge about innovations and is not very willing to try new things, so they are

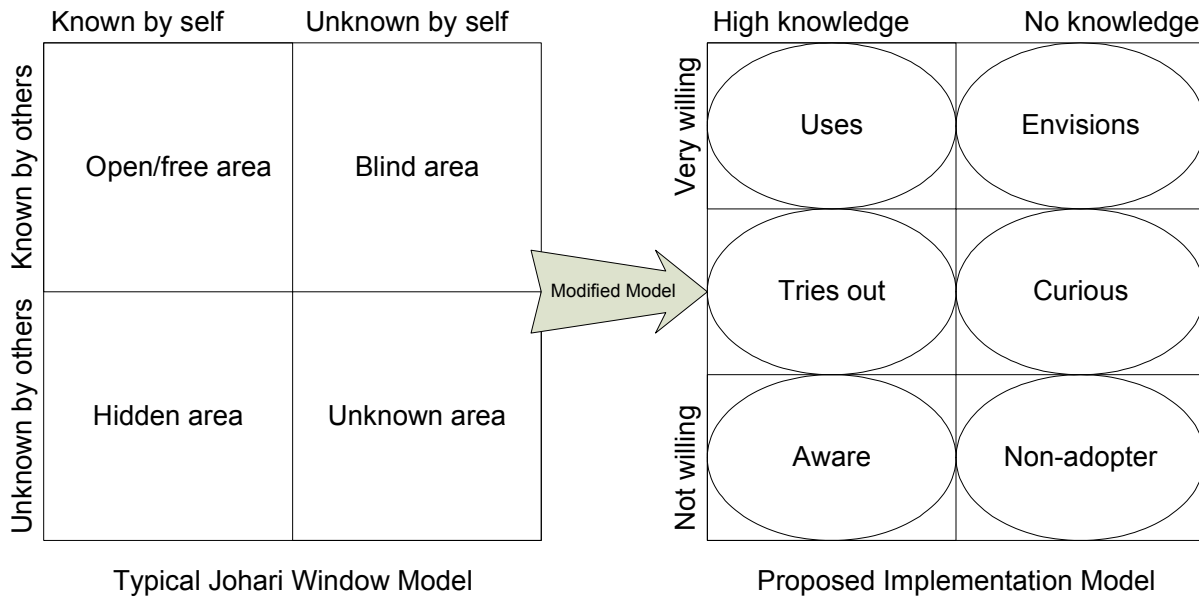


Figure 3. Typical Johari Window Model and Proposed Implementation Model

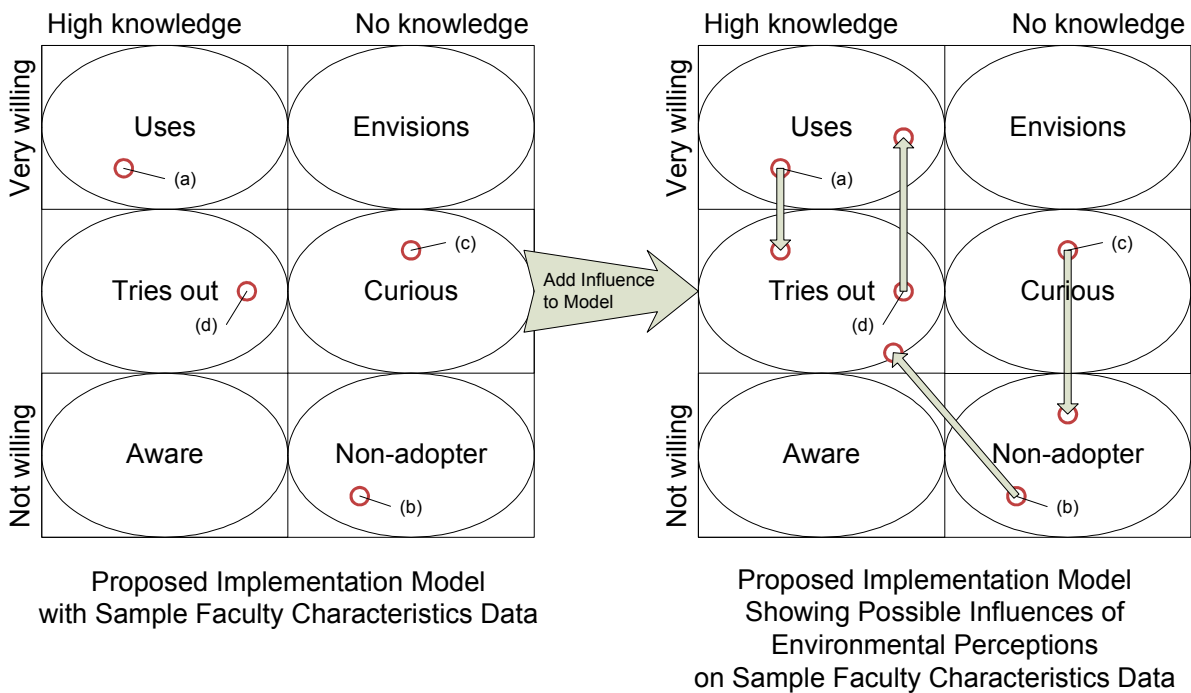


Figure 4. Proposed Implementation Model with Sample Data and Possible Influences of Environmental Perceptions

likely to be a non-adopter. With incentives, rewards, and/or other positive perceptions about their environment and the support it provides, they may increase in both knowledge and willingness, possibly resulting in a trial of a new innovation. Individual (c) exhibits little knowledge about engineering education innovations and a moderate willingness to adopt. They are classified as curious in the stages of adoption. Their environmental perceptions may cause their willingness to decrease to the point where they choose not to adopt. Individual (d) is willing to try out innovations (moderate knowledge and moderate willingness). Positive environmental perceptions may change this person into a regular user of innovations in their classroom.

The overall goal of this phase of the project is to develop an implementation model aimed at increasing the number of faculty successfully adopting education innovations. The model proposed above provides an opportunity to characterize and benchmark the range of stages of adoption that faculty members exhibit. By illustrating the influence faculty members' perception of the work environment has on their behavior, this project promotes a realignment of individual and institutional priorities. Essentially, as an engineering community, we are aiming to have as many data points as possible in the upper left (uses) panel. There are two ways to achieve this:

- (1) have numerous faculty that exhibit characteristics implying adoption of innovation and no (or small) negative perceptions of the environment. This is illustrated by point (a) on the left side of Figure 4.
- (2) ensure that the perceived environment is supportive and rewards individuals for adopting innovations, encouraging those faculty members who might not be adopters by default to become adopters. This is illustrated by point (d) on the right side of Figure 4. Point (b) may also eventually end up adopting in the future as well.

Task 2 – Validation of Model. To validate the implementation model, we need to answer the question: 'Does the model correctly emulate the behaviors of the real world system it is supposed to represent?' We want the model to accurately show information about the system and be useful to others. There are a number of ways to go about validating a model such as the one we propose.

The first method of validation is to set aside a portion of the data collected and use it only to validate the model. This is not a good option for this project for several reasons. We have a very limited amount of data we are collecting (sample is 70 faculty) and reserving some of that data for validation means that our sample is even smaller. Also, our model is really only providing a benchmark for where individual faculty members' knowledge and willingness lies, and how their perceptions influence those measures. Checking the model by looking at more data will not provide any proof that the model is reasonable; it will only provide more data. This method is much more effective in quantitative research where the model is more likely to be equation-based. Consequently, we have not chosen this method for validation.

A similar method of validation is to gather additional data from another source to use as a measure of comparison. This method has the same flaws as reserving a portion of our collected data and will also not be used. This method would be useful in future research, not to validate the model itself, but to see if the trends found in this work (i.e., the trends that would be shown in a completed model similar to Figure 4) are consistent in different environmental settings (i.e.,

different universities). This would allow researchers to see similarities and differences in the barriers that are exhibited due to environmental perceptions. It is reasonable and acceptable that there would be differences, as each setting may have its own challenges and barriers to overcome when tackling the problem of improving the transfer of engineering education research to practice.

A third method of validation is to use experts to review the model. We will be using this method. We will use expert opinions gathered from the Center for Teaching and Learning at BSU to determine in which stage of adoption a faculty member is located. We will assign each individual as a non-adopter or to one the five stages of adoption (aware, curious, envisions, tries out, uses), as our model includes these stages. This categorization is different than that performed earlier in the data analysis. There, we defined the dichotomy of success/failure as a dichotomy of adoption/non-adoption so we could look at faculty member characteristics and perceptions of work environments that were consistent with that success or failure. Here, we are interested in validating a model showing where each individual currently stands with respect to adoption and how perceptions of the work environment influence the likelihood to adopt, with the intent to close the gap between the two.

Once we have categorized each faculty member into one of the six categories described above, we will compare that classification to their location on the model based on their knowledge and willingness. If the locations on the model match the classifications from experts, we have successfully validated that portion of the model. If the locations and classifications do not match, we will need to readjust our model. As an example, from Figure 4 individual (d), based on her level of knowledge and her willingness, was shown in the model to 'try out' new engineering education innovations. The expert classification should match that this person tries out innovations.

Because we are basing successful validation on a comparison of knowledge and willingness vs. classification by experts, we must validate the knowledge and willingness portion of the model as well. This validation is done through data triangulation, method triangulation, and investigator triangulation²¹. Data triangulation is the use of multiple data sources. Examples of this in our project include the collection of data from colleagues and from students. We will make use of many points of data collected from different sources (people) on this project, improving the validity of the data. Method triangulation is the use of multiple methods to collect data. This project collects data through self-report surveys, focus groups, interviews, and document analysis, again improving the validity of the data. Investigator triangulation involves the use of multiple investigators to collect and interpret the data. When the investigators all agree on the results from interpretation, the validity of the results are less likely to be in question. We will make use of investigator triangulation when determining a faculty member's knowledge about and willingness to use new engineering education innovations.

We will similarly use data triangulation, method triangulation, and investigator triangulation to validate the influence that work environment perceptions have on a faculty member's knowledge about and willingness to use new engineering education innovations.

Expected Significance

Identifying faculty characteristics of successful adopters of new engineering education innovations, and those of non-adopters, combined with understanding influences of work environment perceptions provides insight into the varied perspectives of stakeholders involved in the larger transformation of engineering education. Only with an understanding of these diverse perspectives can change be successful on a larger scale, as most organizational level changes fail due to people (cultural) issues²².

Studying the culture of people within an engineering institution is not common, but it is important to understand what the culture is before it can be successfully changed. By studying the current culture, this work adds to the theories related to adoption and diffusion of innovations, change management, and attitudinal-behavioral theories. Additionally, the process and models identified in this study are scalable to all domains involved in invention-to-innovation transformations.

This work will aid in the promotion of a realignment of individual faculty member and institutional priorities with those of the larger engineering community. When the priorities of individual faculty members match with the priorities of their work environment, and these both align with the goals of the larger community, we will have bridged the gap over the 'valley of death' in engineering education innovation. This project will serve as the foundation on which the complete bridge from engineering education research to successful implementation can be built.

The proposed work also provides much needed benchmarking for continued research in the area of engineering education transformation. The American Society for Engineering Education and the National Academy of Engineering have already defined where engineering education should head^{4, 5}. This project allows us to see where we are and what we need to overcome to move forward. As engineering education research is adopted in the classroom and teaching becomes more all-inclusive, participation in engineering is likely to broaden and include more underrepresented groups⁹, benefiting society as a whole.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. EEC-1037729. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. Ford, G.S., T.M. Koutsky, and L.J. Spiwak. (2007). "A Valley of Death in the Innovation Sequence: An Economic Investigation." Phoenix Center for Advanced Legal and Economic Public Policy Studies.

2. Auerswald, P.E. and L.M. Branscomb. (2003). "Valleys of Death and Darwinian Seas: Financing the Invention to Innovation Transition in the United States." *Journal of Technology Transfer*, 28, 227-239.
3. Fincher, S.A. (2009). "Useful Sharing." *Journal of Engineering Education*, 98(2), 109-110.
4. Watson, K. (2009). "Change in Engineering Education: Where Does Research Fit?" *Journal of Engineering Education*, 98(1), 3-4.
5. Jamieson, L.H. and J.R. Lohmann. (2009). "Creating a Culture for Scholarly and Systematic Innovation in Engineering Education: Ensuring U.S. engineering has the right people with the right talent for a global society." ASEE.
6. Loui, M.C. (2007). "Moments of Inertia: Toward an Agenda for Sociological Research on Why Engineering Professors Resist Changes in Pedagogy and Curriculum." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
7. Fox, M.F. (2007). "Institutional Transformation in Academic Science and Engineering: What is at Issue." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
8. Croissant, J. (2007). "Organizational Contexts and Faculty Behavior: Frameworks for Research on the Social Dynamics of Campus Change." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
9. Spalter-Roth, R., N. Fortenberry, and B. Lovitts. (2007). "The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering." American Sociological Association, Washington, DC.
10. Bowen, D.M. (2007). "Engineering Education Innovations: Modeling the Influence of Organizational Context and Faculty Behavior." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
11. Ambrose, S. (2007). "Exploring the Role of the Reward System in the Diffusion of Innovation in Engineering Education." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
12. Kramer, L. (2007). "Greedy Institutions and Faculty Involvement in Retention." *The Acceptance and Diffusion of Innovation: A Cross-Curricular Perspective on Instructional and Curricular Change in Engineering*, R. Spalter-Roth, N. Fortenberry, and B. Lovitts, eds., American Sociological Association, Washington, DC.
13. Nowack, K.M. (1999). "360-Degree Feedback." *Intervention Resource Guide: 50 Performance Improvement Tools*, D.G. Langdon, K.S. Whiteside, and M.M. McKenna, eds., Pfeiffer, San Francisco, CA.
14. Trumbo, D.A. (1961). "Individual and Group Correlates of Attitudes Toward Work-Related Change." *Journal of Applied Psychology*, 45(5), 338-344.
15. De Meuse, K.P. and K.K. McDaris. (1994). "An Exercise in Managing Change." *Training and Development Journal*, 48(2), 55-57.
16. Malouff, J.M. and N.S. Schutte. (1986). "Irrational Belief Scale." *Sourcebook of Adult Assessment Strategies (1995)*, N.S. Schutte and J.M. Malouff, eds., Plenum Press, New York, 432-435.
17. Rogers, E.M. (1995). *Diffusion of Innovations*, 4th ed., The Free Press, New York.
18. Dormant, D. (1999). "Implementing Human Performance Technology in Organizations." *Handbook of Human Performance Technology*, H. Stolovitch and E. Keeps, eds., Jossey-Bass/Pfeiffer, San Francisco, CA, 237-259.
19. Luft, J. and H. Ingham. (1955). "The Johari window, a graphic model of interpersonal awareness." *Proceedings of the western training laboratory in group development* Los Angeles, CA, UCLA.
20. Goleman, D. (1998). *Working with Emotional Intelligence*, Bantam Books, New York.
21. Johnson, B. and L. Christensen. (2000). *Educational Research: Quantitative and Qualitative Approaches*, Allyn and Bacon, Boston, MA.
22. Maurer, R. (1997). "Transforming resistance." *HR Focus*, 74(10), 9-10.