

A Simulation Model that Decreases Faculty Concerns about Adopting Web-Based Instruction

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ABSTRACT

Faculty members have different concerns as they integrate new technology into their teaching practices. The integration of Web-Based Instruction in higher-education settings will not be successful if these faculty concerns are not addressed. Four main stages of faculty concern (information, personal, management, and impact) were identified based on Hall's concern-based adoption model. By reviewing the literature on the diffusion of on-line education, the author identified support factors that may decrease faculty concerns about adopting WBI. System dynamics was used to examine associations between faculty concerns and these support factors. Based on these associations, a simulation model was built using STELLA to test the potential impact of support factors on the adoption of WBI by faculty members. The simulation model will aid educators and administrators in evaluating the impacts of support factors on the adoption of WBI.

Keywords

STELLA software, Adoption of WBI, Supporting factors for adoption of technology, Faculty concern, System dynamics

Introduction

Web-Based Instruction (WBI) has experienced explosive growth, and its use is becoming more attractive in higher education settings. Many innovation models have been proposed to provide a theoretical framework to facilitate the adoption of a new technology (Fullan, 2007; Rogers, 2003). An important point of view in the models is a person-centered approach (Derntl & Motschnig-Pitrik, 2005). According to Emrick, Peterson, and Agawala-Rogers (1977), two parallel dimensions exist simultaneously in the change process: 1) a systemic dimension that involves change in the environment of the user, and 2) a personal dimension, including cognitive, behavioral, and affective components, that involves the process of change within the individual. The system-centered approach clarifies essential factors that lead to technology integration changes processes (Hsu & Sharma, 2008). However, a common limitation of this approach is that it fails to look at the psychology of the innovation and, thus, the interventions are not persuasive enough to bring about the desired change. Research is needed to identify the personal-dimension variables that affect the adoption of WBI by faculty members (Ertmer, 2005; Georgina & Olson, 2008).

The concerns that faculty members have when deciding whether to integrate new technology are a critical condition that needs to be considered along with other personal dimension variables for the successful adoption of WBI in higher education settings (Adams, 2003; Matthew, Parker, & Wilkinson, 1998; Sahin & Thompson, 2007). The more concerns they have, the more likely they will be resistant to adopt the WBI. For this reason, it is important to identify the factors that can diminish faculty concern about adopting WBI. It is difficult and costly to test the relevant variables in practice, but simulating the impact of the model should allow educators and decision makers to assess the effectiveness of factors that may support the implementation of WBI in educational settings.

The purpose of this article is to propose a simulation model designed to test the impacts of the factors that support faculty adoption of WBI integration. In order to achieve this purpose, the stages of concern of the faculty members were identified using the Concern-Based Adoption Model (CBAM) (Hall, George, & Rutherford, 1977). The factors that support faculty WBI adoption regardless of the stage of concern were then suggested. These identified factors were based on a review of the literature on the diffusion of online education. System dynamics was used to determine associations between faculty concerns and these support factors. Finally, based on the identified factors that occur during the different stages of concern, a simulation model with examples of its use is presented.

Factors that decrease faculty concerns about adopting WBI

Faculty concern about integrating WBI

What concerns do faculty members have as they integrate new technology into their courses? According to Fuller (1969), the process of diffusion can be explained in terms of a psychological shift from the properties of an innovation to the concerns of the users. He initially proposed a model that described three phases of concern: a pre-teaching phase, an early teaching phase, and a late teaching phase. These three phases were later named "self," "task," and "impact" concerns, respectively. Hall, George, & Rutherford (1977) expanded upon these three stages of concern to end up with a total of seven stages. According to these stages, adopters advance from lower-level, self-oriented concerns (awareness, informational, and personal) to intermediate-level, task-related concerns (management), and finally to impact concerns (consequence, collaboration, and refocusing). In the awareness stage (Stage 0), a person has either little knowledge of or little involvement with the innovation. Self concern refers to the questions we ask when we hear about an innovation (Stage 1, informational) and think about how the innovation may affect us (Stage 2, personal). Task concerns emerge as we learn new skills such as time management and material usage (Stage 3, management). Impact concerns describe our thoughts on how we can make an innovation work better for our students (Stage 4, consequence), how to make it work better by actively improving it with colleagues (Stage 5, collaboration), and, ultimately, how to be successful with the innovation and seek out positive changes to implement (Stage 6, refocusing).

WBI, for the purpose of this paper, is the use of Web-based computer devices such as desktop computers, laptops, handheld computers, software, the Internet, and Learning Management Systems for instructional purposes (Hew & Brush, 2007). It is defined as a type of blended learning in which a significant portion of instructional activities is delivered online but traditional classroom instruction is not eliminated (Garnham & Kaleta, 2002). Most faculty members are expected to have concerns when integrating WBI into their teaching. However, these concerns will be different according to the stage of the adoption process they find themselves in. Rogers (2003) presented the steps in the innovation process as follows: knowledge, persuasion, decision, implementation, and confirmation. In general, when people are confronted with a new technology, they will gather information, test the technology, and then consider whether the new technology is a sufficient improvement to warrant the investment of their time and energy to learn the skills required to use it (Rogers, 2003). Based on Roger's innovation process, five different categories of faculty members are assumed to appear in the WBI adoption process: 1) Faculty Unaware, who have little interests in the adoption of WBI, 2) Faculty Aware, who are aware of WBI and gather information about it, 3) Faculty Adopters, who apply WBI to their teaching, 4) Faculty Implementers, who regularly use WBI, and 5) Faculty Integrators, who are interested in extending the use of WBI in their teaching practices.

Based on Hall's (1978) concern-based adoption model, faculty members are expected to experience different concerns during the process of innovation: *awareness concerns* for Faculty Unaware, *information concerns* for Faculty Aware, *personal concerns* for Faculty Adopters, *management concerns* for Faculty Implementers, and *impact concerns* for Faculty Integrators. Hall's last three stages of concern (consequence, collaboration, and refocusing) were combined into one concern, called the *impact concern*, in this study because faculty members experience all of these concerns after adopting the technology into their classrooms.

Support factors that decrease faculty concerns about adopting WBI

How can we reduce these WBI-related concerns? Previous studies have suggested various factors that may contribute to technology adoption (Inan & Lowther, 2010; Ngai, Poon, & Chan, 2007; Sahin & Thompson, 2007; Selim, 2007; Wang & Wang, 2009). These factors include staff development opportunities, time, prompt technical, incentives and positive attitudes towards the technology (Buckenmeyer, 2001), improved student learning, equipment availability (Hew & Brush, 2007), ease of use, time needed to learn the skills required to implement the new technology, compatibility with materials, training, administrative support, personal comfort and colleague use (Olapiriyakul & Scher, 2006), perceived value, available resources and communication with other adopters (Keengwe, 2007), mission statements and institutional culture, faculty development programs (Kahn & Pred, 2000), personal conviction, motivation and experience, and organizational support. According to Bradshaw (2002), different support factors are needed based on the faculty member's stage of concern. For instance, faculty members that are concerned with information need to know more about the technology. In this study, therefore, the support factors were

categorized according to faculty stage of concern. The following table summarizes the support factors and details the strategies that may decrease each type of concern (Table 1).

Table 1. Faculty Concerns, Support Factors, and Strategies

Faculty Concerns	Support Factors	Strategies
Faculty Unaware (Information Concerns)	Basic training	Basic application software, use of the Internet resources, email and simple course- management software features
	Technology support	Support for hardware and software, access to technical staff, and other equipment availability
Faculty Aware (Personal Concerns)	Intermediate training	Effective use of web-based technology in the classroom, use of course management software, and troubleshooting
	Instructional support	Working with an instructional designer to learn more about the instructional use of technology
Faculty Adopter (Management Concerns)	Peer tutoring	Working with faculty mentors on their projects on an as-needed basis
	Faculty incentives	Funding for technology purchases (hardware and software), financial compensation
Faculty Implementer (Impact Concerns)	Advanced training	Assessment training (how to analyze student performance and evaluation strategies)
	Administrative support	Institutional climate for technology, providing external motivation (e.g., promotion or releasing a course)

Faculty members with information concerns should be given entry-level information via available media, individually or in groups. At this stage, faculty members need basic training and technology support. *Basic training* includes downloading presentation software and learning how to develop simple presentations, and use Internet resources, e-mail, and simple course management software features, such as creating a syllabus. *Technology support* is also important to reduce this type of concern, which includes hardware and software support, access to technical staff for Web-based course development and Web- page development, and personal computers equipped with the required software applications (Hew & Brush, 2007; Zhao, Pugh, Sheldon, & Byers, 2002).

Faculty members with personal concerns should be granted the opportunity and encouragement to learn and talk about the technology and how to best use the technology. At this stage, the faculty members are in learning mode and need intermediate training and instructional support. *Intermediate training* must have an instructional focus that first guides faculty members to think about their teaching styles and then helps them decide how to integrate the web-based technology into their style of teaching. They must understand how technology can support their educational objectives. The training should help faculty members effectively use web-based technology in the classroom, incorporate creativity in their presentations, use course-management software, and troubleshoot. In addition to training, *instructional support* is needed; faculty members work with an instructional designer to learn more about the instructional use of technology and to design, develop, and evaluate technological applications.

Faculty members with management concerns need practical help in developing and implementing web-based activities. The strategies used to reduce the management concerns include peer tutoring, administrative support and incentives. *Peer tutoring* involves faculty mentors working individually with those seeking help on their projects on an as-needed basis. This encourages faculty members to “share expertise, perspectives and strategies with each other” (Newcombe & Kinslow, 2000). *Faculty incentives* include funding for technology purchases, providing promotion/tenure as external motivation for faculty members who integrate new technology methods, and time to a) develop and maintain the web-based technology, b) learn more about the technology, and c) attend training sessions and any other support activities. Lack of administrative support is often cited by faculty members as a key barrier to adopting new technology (Dooley & Murphrey, 2000). *Administrative support* involves creating an institutional climate conducive to technology use, and providing equipment.

Finally, faculty members who have impact concerns need to be involved in envisioning and planning the use of the technology (Bradshaw, 2002). The strategies used to reduce impact concerns should focus on decreasing all three types: consequence, collaboration, and refocusing. They consist of advanced training and administrative support. *Advanced training* aims to provide information on analyzing students’ performance and on evaluating different strategies. *Administrative support* should provide opportunities for faculty members to work together each other so

that they can share the knowledge and skills that they have learned, and should improve the quality of instructional and administrative support (Keengwe, 2007).

Modeling the WBI adoption process with system dynamics methodology

In this study, a system dynamics approach was adopted to investigate the behaviors of faculty members as they adopt WBI. System dynamics is a method used to enhance the learning of complex social systems by helping interested persons to learn about the complexities involved, understand the sources of resistance to policies, and design more effective policies (Sterman, 2000)

An important step towards understanding a complex social system is determining policy structure. A policy structure needs to be created to represent the complexity of a certain system (Richardson, 1996). From the perspective of policy structure, an aggregated policy-structure diagram of the WBI integration model is presented in Figure 1; it demonstrates the conceptual representation of the associations among faculty groups and concern rates.

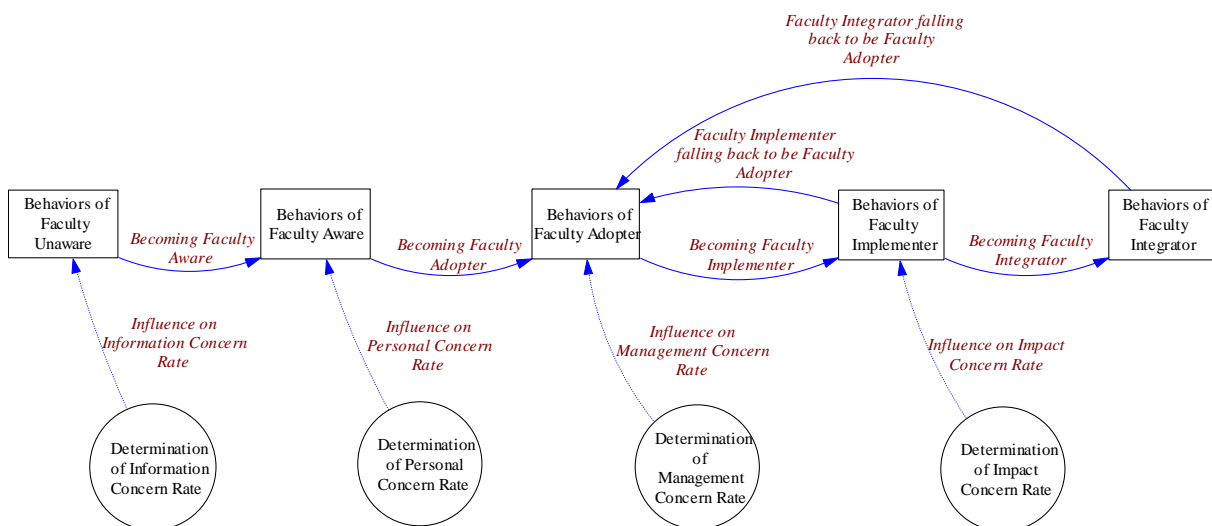


Figure 1. A policy structure diagram that show the associations among faculty concern rates

In the policy-structure diagram, the rectangular sectors represent the structures by which the behaviors of faculty members are determined by several variables. The circular sectors in the diagram represent the structures by which rates of concerns are determined by a number of associated variables. The solid lines represent the material or physical flows that move between the sectors, faculty members. The lines represent information flows transmitted among sectors and the effects of the concern rates. For instance, the Impact Concern Rate is based on the values of the two associated factors, “Advanced training” and “Administrative support for impact.” After the value of the Impact Concern Rate is decided upon, the sector sends information, the “Influence on Impact Concern Rate,” to the “Behaviors of Faculty Implementer” sector. The faculty members in the “Faculty Implementer” group then decide their behaviors based on the information they receive from the other sectors. These potential behaviors include moving forward to become “Faculty Integrators” or falling back to become “Faculty Adopters.” The core assumption is that the more “Advanced training” and “Administrative support for impact” that are provided, the lower the “Impact Concern Rate” will be. As a result, more “Faculty Implementers” are moving forward to become “Faculty Integrators” than are falling back to become “Faculty Adopters.”

Another key concept involved in understanding a complex system is feedback structure, i.e., the causal relationships among variables (Richardson, 1996). There are two kinds of causal loops: positive/reinforcing loops and negative/balancing loops. A change in the value of a particular variable in a positive loop will result in a behavioral change in the system that will eventually strengthen the original change. On the other hand, a change in the value of a particular variable in a negative loop will result in a behavioral change in the system that will eventually counteract or weaken the original change. A causal loop diagram for WBI integration is shown in Figure 2. The arrows in the diagram represent the direction of influence. For instance, an arrow that goes from A to B means that A affects B. In

addition, a positive or negative sign next to an arrow implies that a positive or negative association exists between the two connected variables. When two variables are positively related, they behave in the same manner, meaning that as the value of one variable increases or decreases, the value of the other variable increases or decreases as well.

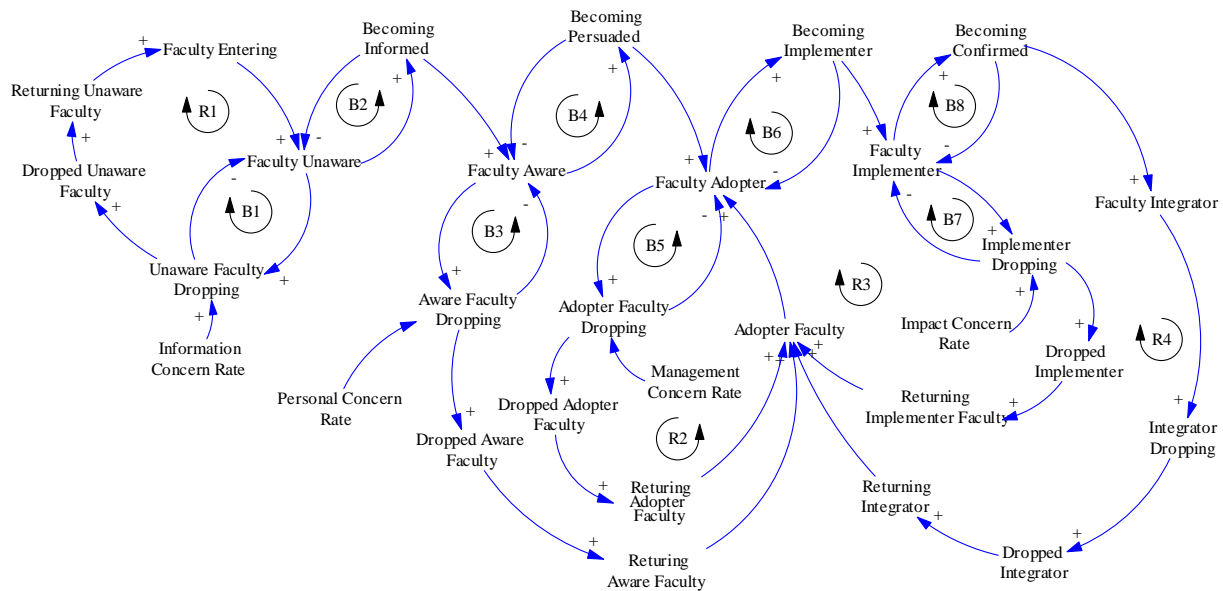


Figure 2. A causal loop diagram of WBI integration

For example, when the value of “Faculty Entering” increases, the value of “Faculty Unaware” also increases since “Faculty Entering” has a positive effect on “Faculty Unaware.” Similarly, when the value of the “Faculty Entering” decreases, the value of the “Faculty Unaware” decreases as well. As we discussed previously, there are two types of feedback loops used in the model: reinforcing positive loops, which are referred to as (R) loops, and balancing negative loops, which are referred to as (B) loops. Take the R1 loop, for example: when the value of “Faculty Unaware” increases, the values of the “Unaware Faculty Dropping” and the “Dropped Unaware Faculty” variables also increase. An increase in the value of “Dropped Unaware Faculty” results in increased values for both “Returning Unaware Faculty” and “Faculty Entering,” which will eventually lead to a further increase in the value of the “Faculty Unaware.”

In line with the notions of complex social systems and feedback-loop structures that have been proposed, this study considers the adoption of WBI by faculty members as a complex social system that involves various interactions among a number of relevant factors. A system dynamics approach provides both individual faculty members and decision makers/administrators with comprehensive insights into how the indicated relevant factors affect the level of their concerns regarding WBI and as a result influence the behaviors of the faculty members during the WBI adoption process.

A simulation model that tests the impacts of support factors

Structure of the simulation model

A simulation model was constructed to investigate the impacts of the factors that decrease faculty concerns about adopting WBI in higher-education settings. Because simulation is flexible enough to accommodate faculty dropout, constraints and uncertainty in the model, and testing of potential impacts of the parameters in the model, simulation-based methods are employed in this study rather than actual data-collection methods such as surveys and interviews. The STELLA modeling software was chosen to build the WBI adoption process model. STELLA has several advantages over other simulation modeling software, including an easier graphical interface, better classification of variables in the system, easier description of the relationships between variables, an automated process for running computations, and the ability to visualize results with graphical output (Carr-Chellman, Choi, & Hernandez-Serrano,

2001; Ruth & Lindholm, 2002). STELLA allows the researcher to view the simulation variables and stock-and-flow structures in terms of the causal relationships among them (see Figure 3).

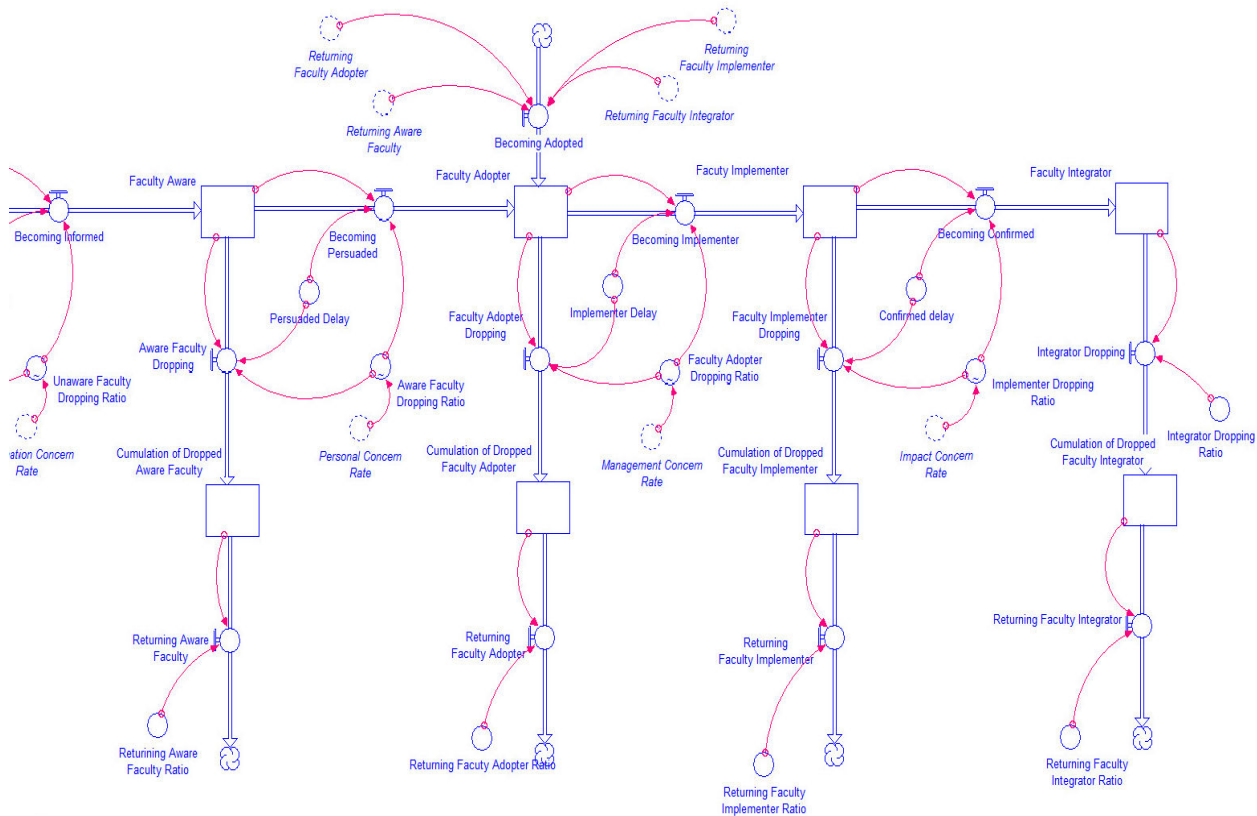


Figure 3. Structure of the WBI system built using the STELLA® modeling software

In this model, all faculty members are classified into one of five faculty groups based on their experience with WBI: “Faculty Unaware,” “Faculty Aware,” “Faculty Adopter,” “Faculty Implementer,” and “Faculty Integrator.” In addition, four main faculty concern rates (Information Concern Rate, Personal Concern Rate, Management Concern Rate, and Impact Concern Rate) are included in the model based on their individual effects on the behaviors of particular faculty groups. Support factors were incorporated into the simulation model at different concern stages during the adoption process. For instance, a Faculty Adopter may experience a management concern as he or she moves toward being a Faculty Implementer, his or her concern rate would be determined based on the combinations of three support factors: the effects of the administrative support for management, the effects of faculty incentives, and the effects of peer tutoring.

User interface of the simulation model

A user-friendly interface was developed for the proposed model that is easy for administrators and faculty members to operate. The interface was designed to help users develop a general understanding of WBI through customized simulations and may also be used to help administrators select appropriate policies to facilitate the use of WBI. The interface, as presented in Figure 4, includes two main parts: the parameter adjustment and the simulation outcome.

The parameter adjustment, which is located at the bottom of Figure 4, includes four divisions that correspond to the different levels of faculty concerns: “Information Concern Factors,” “Personal Concern Factors,” “Management Concern Factors,” and “Impact Concern Factors.” Each concern rate can be changed by adjusting the slide bars that represent the key support factors affecting each concern rate. For example, for the support factor, Basic Training, which falls under “Information Concern Factors,” a user can select a value between 0 and 30, indicating the total number of hours of technical training per semester. The ranges used were determined based on a review of the

literature on the diffusion of online learning and technology integration. Table 2 summarizes the support-factor ranges included in the simulation model. The default value for “Basic Training” is 15 hours per faculty member per semester. If an administrator intends to increase the number of training hours to 20 hours per semester, then the slide bar should be set to 20. The parameter adjustment also includes a brief description of each variable; for example, the “Technology Support” factor, which falls under “Information Support Factors,” includes the information that one technician should be provided for every 100 faculty members. By referring to the brief descriptions provided, a user will understand the meaning of the variable “Technology Support” and make the proper adjustments for his or her simulation. For example, by setting the value of “Technology Support” is set to 5, the user assumes that for every 100 faculty members a total of five technicians are assigned to provide technical support.

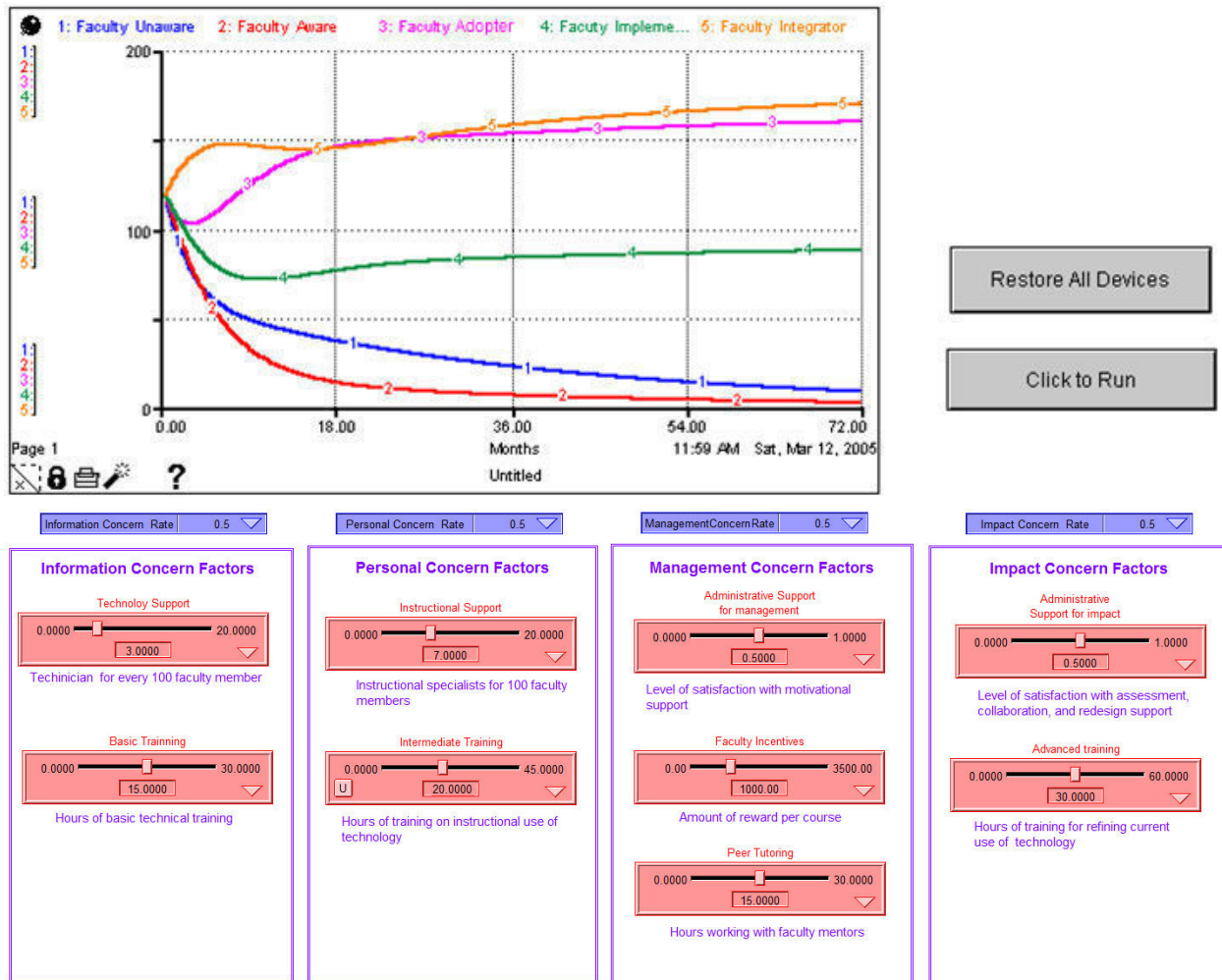


Figure 4. Simulation model interface

The simulation outcome, which is located at the top of Figure 4, shows the results of the simulation. Users can select values for all the variables based on their own assumptions, and click the “Click to Run” button at the bottom to run the simulation. The model then automatically performs the requested simulation and generates corresponding graphs and numerical information when the simulation is complete. The X-axis represents the time period for the simulation; for example, the X-axis of the graph in Figure 4 which has an index of 0 to 72 indicates that the simulation time frame is 72 months. The Y-axis of the graph represents the values of the five faculty groups at individual points of time. On the top of each of the four sections of concern factors, an information display bar is presented to show the assigned value of the concern rate associated with a particular section in a particular simulation. For instance, the “Information Concern Rate” is 0.5, as shown on the information display bar, when the value of the “Technology Support” is equal to 3 and the value of the “Basic Training” is equal to 15.

Table 2. Ranges for Support Factors

Support Factor	Factor	Range	Unit
Information Concern Rate	Technology Support	0-20	Technicians for every 100 faculty members
	Basic Training	0-30	Hours of basic technical training
Personal Concern Rate	Instructional Support	0-20	Instructional specialists for every 100 faculty members
	Intermediated Training	0-45	Hours of training in instructional use of technology
Management Concern Rate	Administrative Support	0-1	Level of satisfaction with motivational support
	Faculty Incentive	0-3500	Amount of reward per course
	Peer Tutoring	0-30	Hours working with faculty mentors
Impact Concern Rate	Administrative Support	0-1	Level of satisfaction with assessment, collaboration, and redesign support
	Advanced Training	0-60	Hours of training for refining current use of technology

Examples of the simulation run

The simulation environment for the base run was developed based on a university with a total of 600 full-time faculty members. Since it was difficult to determine the specific number of faculty members in each of the five WBI faculty groups, researchers in this study generally assumed that the initial number of faculty members in each of the five WBI faculty groups was the same: 120. Figure 5A shows the result of the base simulation run, in which we assumed that the university administrators provided the proper support and managed to keep all of the concern rates at 0.5. The X-axis represents the time in months, while the Y-axis represents the number of faculty members in each of the faculty groups. Figure 5A shows that the number of faculty members in the Faculty Unaware (Graph 1) and Faculty Aware (Graph 2) groups decreased noticeably over a time period of 18 months, while the number of faculty members in the Faculty Adopter (Graph 3) and the Faculty Integrator (Graph 5) groups increased considerably within the same period of time.

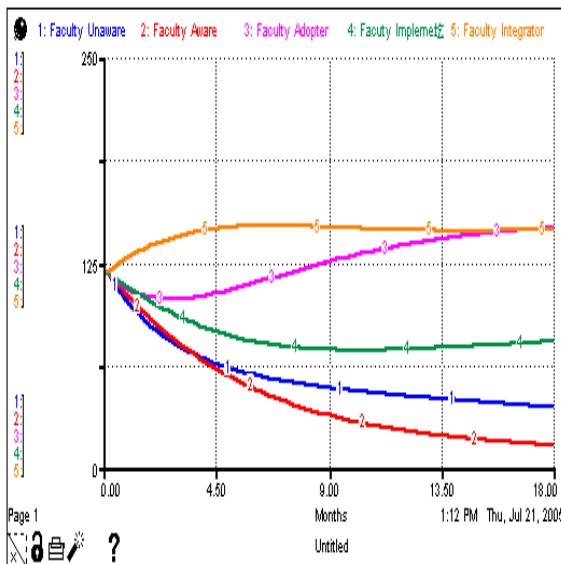


Figure 5A. Base Run

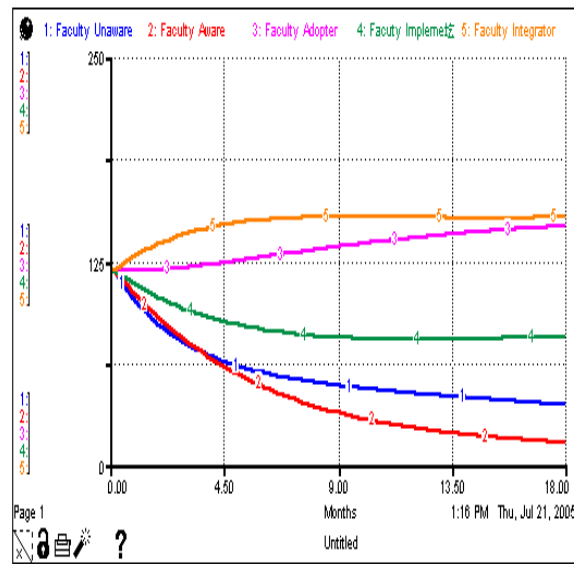


Figure 5B. Simulation Result—First Scenario

For the simulation, researchers created a couple of possible scenarios. In the first scenario, it is assumed that the university administrators intended to encourage the *Faculty Aware* individuals, the faculty members who have been aware of WBI, to become *Faculty Adopters*, that is faculty members who have started to use WBI, within a relatively short period of time. As a result, the university administrators aimed to reduce the concern rate of the individuals in the Faculty Aware group (the personal concern) to 0 by providing the maximum level of “Instructional Support” and “Intermediate Training.” Figure 5B shows the results of the first simulation run. The results indicate that the number of Faculty Adopters (Graph 3) dramatically increased over the first four months. This result implies that more faculty members will adopt WBI when suggested supports such as “Instructional Support” and “Intermediate Training” are provided.

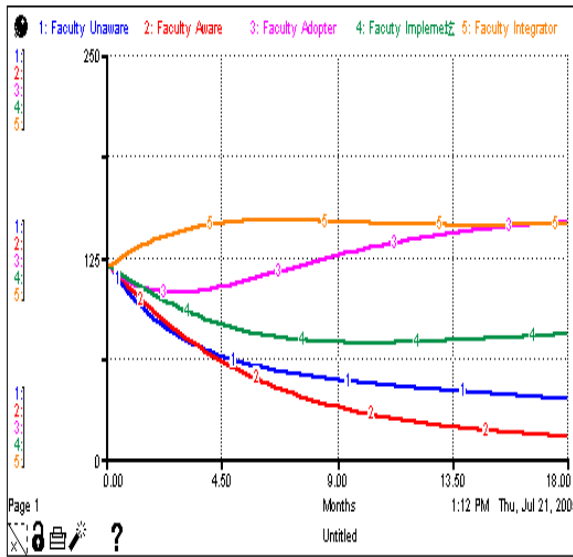


Figure 6A. Simulation Result—Base Run

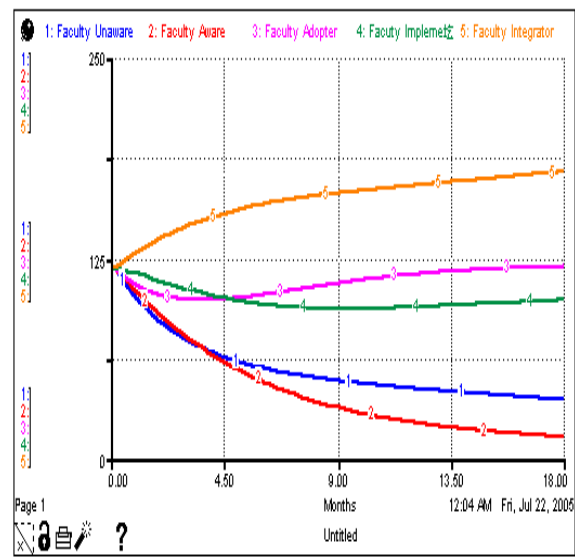


Figure 6B. Simulation Result- Another Scenario

In another scenario, it is assumed that the university administrators were planning to encourage more *Faculty Adopters*, faculty members who have been starting to apply WBI, to become *Faculty Implementers*, that is, faculty members who regularly use WBI in their teaching practice, within a relatively short period of time. As a result, the university administrators aimed to reduce the concern rate of the Faculty Adopters (management concern) to 0 by providing them with the maximum levels of the relevant types of support: “Administrative Support for Management,” “Faculty Incentives,” and “Peer Tutoring.” Figure 6B shows the results of this simulation run. The result indicates that the numbers of both Faculty Adopters (Graph 3) and Faculty Implementers (Graph 4) increased within the same period of time. This implies that more “Faculty Adopters” are persuaded to become “Faculty Implementers” when the management concern rate is decreased to 0. The results of the simulation also show that a decrease in the management concern rate smoothes the progress of faculty members adopting WBI. For instance, in Figure 6B, the total number of “Faculty Integrators” (Graph 5) jumps to around 180 in the eighteenth month. After the fourteenth month, the majority of the faculty members choose to become “Faculty Adopters,” “Faculty Implementers,” or “Faculty Integrators.”

Conclusion

The main purpose of this simulation model was to show administrators and other decision makers how a change in the type of support factors provided to faculty can affect the adoption of WBI. This model will help administrators to better understand the dynamics of the various related to the adoption of WBI by their faculty members. By using this model, administrators can plan how many faculty members can move from one stage to the next within a predetermined time period. These results will provide them with the evidence they need to persuade as many faculty members as possible to become faculty integrators and will convince them to fund workshops and improve incentives to allow new technology to be adopted. Although this simulation model was designed mainly to help administrators of educational institutions make good decisions that will result in increased use of WBI, it is also

expected to be useful for individual faculty members. By using this simulation model, individual faculty members can get an idea of the kinds of support factors available and how much these factors may decrease their concerns. For example, a faculty member with information concerns could identify the best combination of support factors to lower those concerns and request that administrators provide those support factors such as more technology support and basic training opportunities. The model will help researchers and educational administrators to diagnose and evaluate the potential impacts of factors that are predicted to lower faculty concern and contribute to the successful adoption of WBI by the entire faculty.

The simulation model developed for this study suggests several possibilities for future studies. First, a more accurate model that represents the actual change process should be developed, since unknown factors may still remain. More specifically, further efforts such as surveys and interviews with faculty members are needed to clarify the factors that affect each stage of concern. Second, future studies should include relative importance of the support factors in the model. Because the each support factor may have somewhat different significance, future studies should include the relative importance that each factor may have when it is used in the model. Third, interrelations between factors should be thoroughly investigated. It is assumed that each support factor such as faculty incentives and peer tutoring contributed individually to decreases in faculty concerns. However, in practice, these factors may be interrelated and thus, future studies should identify these interrelationships. Therefore, future study should find the interrelationships. Lastly, more factors should be incorporated into the model. Each factor may include various sub-factors, and future studies should include sub-factors that may affect the concerns of the faculty members in order to build a better representative model of what occurs in reality.

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