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A Framework for Addressing Challenges to Classroom Technology Use

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Creating effective learning environments with technology remains a challenge for teachers. Despite the tremendous push for educators to integrate technology into their classrooms, many have yet to do so and struggle to find consistent success with technology-based instruction. The challenges to effective technology integration have been well-documented in the literature. In this article we present a comprehensive review of the literature on the challenges associated with effective technology integration in the classroom and the ways in which they interact with one another. Based on this review we have developed a framework, the Individualized Inventory for Integrating Instructional Innovations (**i^{5}**), to help teachers predict the likelihood of success of technology-based projects in the classroom and identify potential barriers that can hinder their technology integration efforts. Identifying potential barriers upfront can empower teachers to seek solutions early in the process, thereby increasing the likelihood of experiencing success with technology integration.

Introducing a new technology into the classroom in order to transform teaching and learning has been a long-standing tradition in education.

Classrooms and educators alike have seen technologies (e.g., radio, television, etc.) come and go, innovations tried and tossed out. Some technological innovations had strong support to be used in the classroom, others have not. Some have stayed, some have not. However, no other instructional tool has been at the center of an educational revolution like the computer, nor has any other innovation been as invested in, supported, criticized, and researched as the computer (Tyack & Cuban, 2000). It is clear that computer technology will not be tossed out so quickly. What is more likely is that the pressure to increase computer use in the classroom from researchers, reformers, policy-makers, and private-sector developers will steadily intensify (Cuban, 2002; Loveless, 1996).

Despite increased investments in technology, the statistics of classroom computer use are disheartening to say the least. Recent studies indicate that on average, teachers use computers several times a week for preparation but only once or twice a year for instructional purposes (Russell, Bebell, O'Dwyer, & O'Connor, 2003). These statistics raise quite a conundrum; *why is there such a large disparity between classroom professional and instructional use of computers?* Why is it that so many teachers use computers to increase their own efficiency and productivity, yet do not strive to find effective applications for their use as instructional tools? *What is it* that keeps teachers from making this quantum leap?

The answer to these questions are multifaceted. Several authors have already provided a long list of factors influencing the integration of technology into classroom instruction. Some authors have also attempted to organize these factors into a coherent model that demonstrates the ways in which they interact with one another (Zhao, Pugh, Sheldon, & Byers, 2002). While this work is important in guiding research and policy, its practical implications for teachers are rarely well articulated. In this article, we provide a comprehensive review of the literature on the factors or challenges associated with effective technology integration in the classroom and the ways in which they interact with one another. More importantly, we organize this information into a coherent framework, the Individualized Inventory for Integrating Instructional Innovations (**i^5**), which can provide practical assistance to teachers as they navigate the complex and messy process of technology integration. By using the **i^5**, teachers can identify and address potential challenges associated with the implementation of technology-based projects in the classroom, thereby increasing the likelihood of achieving success in technology integration.

FACTORS INFLUENCING CLASSROOM TECHNOLOGY USE: A REVIEW OF THE LITERATURE

Why aren't computers an essential tool in every classroom? What factors influence teachers' success in technology integration?

A review of the literature has produced six critical factors, each with its own variables, that influence the implementation of technology and a teacher's ability to successfully integrate innovations in the classroom (Figure 1): (a) legislative factors, (b) district/school-level factors, (c) factors associated with the teacher, (d) factors associated with the technology-enhanced project, (e) factors associated with the students, and (f) factors inherent to technology itself. While all dimensions are undoubtedly important, not all of them have the ability to be manipulated or accounted for by individual teachers. The *legislative factors*—those attributed to policy, legislation, and research—exist outside the district or school boundaries and, therefore, cannot be easily manipulated by individual teachers. The same is true for factors inherent to *technology* itself. Although the characteristics of various types of technologies can facilitate or hinder efforts to use technology, teachers cannot directly influence or alter those characteristics. Other factors, however, are closer to teachers' immediate experiences and can be directly manipulated or addressed to create an environment that can facilitate the process of technology integration. According to Zhao et al. (2002), those are factors associated with the: (a) school environment or the *Context* in which technology will be implemented; (b) the teacher who serves as the *Innovator*; and (c) the technology-enhanced project or *Innovation*. In this work, we argue that factors associated with the student population are also within teachers' immediate experiences and could be potentially addressed. We refer to the students as the *Operators* of the technology innovation.

In this section, we report our literature findings on how each of the six factors presented in Figure 1 influences the implementation of technology-based projects into classroom instruction. In our discussion, we pay closer attention to the four factors—the Context, the Innovator, the Innovation, and the Operators—that can be directly addressed by the teacher. Those factors are highlighted within the dotted area of Figure 1.

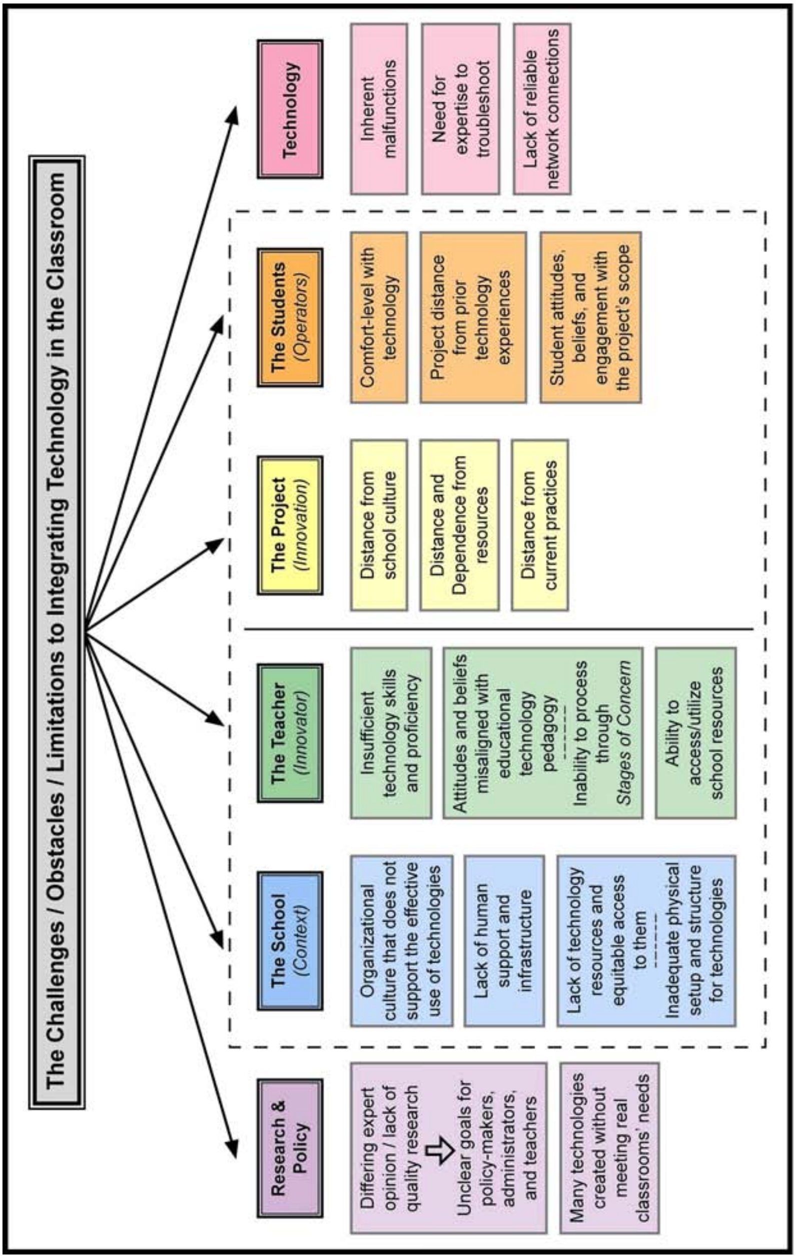

Figure 1. Challenges to classroom technology integration based on existing literature

Legislative Factors

Why should we use resources to support technology integration? What evidence do we have that technology can enhance teaching and learning?

Policy. Over the last two decades policy-makers have articulated different rationales for the integration of technology into the school curriculum. These rationales often emphasize three key themes: (a) using technology to address challenges in teaching and learning, (b) using technology to foster changes in the content and quality of teaching and learning, and (c) using technology to prepare students for an increasingly technological world (McMillan-Culp, Honey, & Mandinach, 2005). Concrete recommendations on how to achieve these goals, however, are rarely included in policy reports, thereby making it difficult to draw any practical implications.

The focus on technology in schools has also ebbed and flowed in the past several years as a result of high-stakes testing. Since technology itself is not directly assessed and attached to consequences through state testing, the political focus has waned from this area[1]. However, much of national dialogue on the critical need for students to develop 21st century skills has only escalated since the introduction of No Child Left Behind. The challenge lies in that the classroom practices to meet each of these goals do not line up, and many educators do not feel they have the ability to develop rigorous, integrated, technology-based projects while still working towards the goals of annual state testing.

Research. While most researchers agree that technology can change the teaching process, making it more flexible, engaging, and challenging for students, little evidence exists to support these claims. Further, it appears that opinions on how to best establish such evidence also differ. Earlier studies followed comparative research designs and sought to find out whether use of computers increased student learning compared to other instructional approaches (Honey, McMillan, & Carrigg, 1999). Such studies treated technology as an isolated addition to the curriculum. Current approaches emphasize the importance of employing research designs that systematically examine computers as one element among other tools in the educational environment. They also emphasize the importance of improved outcome measures that can capture the strengths and weaknesses of students' technology work-products (McMillan-Culp et al., 2005). Until such measures are developed, however, researchers have difficulty providing concrete answers on the efficacy of specific types of technology uses in the classroom in the form that policy-makers require.

In summary, the legislative factors that often prove to be barriers to technology integration in the classroom include the lack of *research* on the efficacy of technology-based instruction and legislative *policy* that shifts frequently or is innately designed to facilitate the introduction of technology in the classroom.

District/School Level Factors

How does district administration and community influence teachers' efforts to implement technology? How does school leadership influence teachers' efforts to implement technology? How can teachers be supported in their efforts to implement technology-based projects?

District administration and community. With the amount of money invested thus far in technology purchases administrators are under a lot of pressure to see these technologies put to use. District officials, local policy-makers, and community members conscious of their tax dollars, want to see fast "returns" on their investment—evidence in outcomes that make the money and effort into getting their school "wired" being worth it (Bowman, 2004; Chaptal, 2002; Zhao & Frank, 2003). Many in these groups have also been vocal on their belief that students should be avidly engaged with computers to be technology-proficient in today's society and as future professionals. Although this view is understandable, it presents teachers with the next obstacle in our gauntlet: *pressure* to use the computer, *often*. Educators, however, must be careful when responding to this pressure. Current research on effective instructional models, such as the *Understanding by Design* (Wiggins & McTighe, 1998), demonstrate that we must place learning goals first and *then* select the tools that best meet those goals (Durost, 1994; McKenzie, 2004; Zimmerman, 2001). In particular, McKenzie (2003) explained that the teacher should: (a) select objectives that support state curriculum standards; (b) identify learning activities likely to deliver the desired outcomes; and (c) select appropriate tools (technologies), whether it be books, pads of paper, Post-It™Notes, or Inspiration™ When this order is reversed and pressure is placed on the teacher to use the tool first and then select an activity to utilize the tool, student learning is often compromised. Successful technology integration is not defined by the *amount*, but by the *nature* of its use (Earle, 2002). Unfortunately, administrators are often more concerned with the frequency rather than the quality of technology use in the classroom (McKenzie, 2003).

Community and parental support can be major factors as well. It is no secret to teachers that parents can be sources of support for the classroom providing assistance in managing the operations of instructional activities. When initiating a technology-based project, this is a resource that should not go untapped. By having parents and volunteers assisting in the facilitation of the project, teachers can be alleviated of time-consuming managerial tasks to focus their energies on guiding student learning (Butzin, 1992).

School environment. *School administration*: Any teacher can testify to the importance of school administration. As directors, administrators influence school structure and culture, constituting the venue for any instructional initiative. Therefore, administrative support (or lack thereof) can make or break teachers' endeavors to integrate technology into the classroom. Collier (2001) described a typical scenario where nine teachers in Shirley, Massachusetts were eager to align the school's standards with technology, but had "no common planning time, no release time, no stipends, and only limited funds to reimburse course work" (p. 67). With minimal support, even the most talented teachers will have little success in technology integration (Becker & Ravitz, 1999; Zhao et al., 2002). The school where these nine teachers reside has an insufficient school culture to support classroom activities. It is the responsibility of the school administration, faculty, and staff to develop their own understanding of technology and learning—and create a working environment that condones these efforts (Collier, 2001).

School administrators should not only advocate the use of technology but also provide support mechanisms such as professional development, time for planning and collaboration, and necessary resources (Earle, 2002; Groves, Jarnigan, & Eller, 1998). Necessary resources include: (a) adequate access to hardware and software; (b) technical and pedagogical support; (c) professional development plans that allocate time and resources for follow-up; and (d) social support from colleagues, including mentoring and time to explore new technologies (Morris, 2002; Zhao et al., 2002).

Administrators who successfully acquire adequate access to resources have taken the first major step toward supporting technology integration. This is what Zhao and Frank (2003) term the *abiotic* technology infrastructure. Unfortunately, access to resources cannot guarantee effective instructional use of technology. For technology-based projects to be effectively implemented, there often needs to be a shift, or redefining, of curricular goals and the establishment of a support network for teachers. Administrators cannot achieve this shift alone. They must establish and lead a network of teachers, technology support personnel, and members from the community, to share in this vision and develop the proper school culture (LeBaron, 2001; Perry & Areglado, 2001). This is what Zhao and Frank (2003) termed the *biotic* technology infrastructure.

Physical structure and technology resources: On the more concrete side of the context, the physical structure of the school can also become a significant obstacle in terms of technology integration. Schools often struggle with how to situate computers and allocate the large amount of space they can demand (Collins, 1996). An example would be the traditional centralized computer lab, a room housing the majority of the school's technology and computers. The problem with this setup is the all too common limited accessibility to the lab, leaving teachers scrambling for time to get their students onto the computers, even though it may not occur at the most opportune time in the technology-based unit (Loveless, 1996).

No matter where these resources are located, the type of technologies available can present significant challenges as well. Very few schools are blessed with abundant technological resources, where each classroom is equipped with the same computer model, peripherals, and at times even software. This can make collaborating with other teachers as well as maintaining and upgrading computers a difficult task. Many of these technologies may not align with the current curriculum as those who make the technology purchases for the school may not be the same people who design the curriculum (Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004). This is where it is critical that a school develop a technology plan, an outline of what hardware and software they will invest in and the design of the infrastructure that will support it. The costs of educational technologies are still exceedingly high and finding basic funding for these innovations is often challenging for schools. Hardware and software acquisitions are front-end expenditures that account for 75% of the costs for financing technology. With minimal funds remaining this leaves schools unable to build an adequate infrastructure—lacking critical electrical wiring, Internet access, and proper installation of technologies (Butzin, 1992; Zhao et al., 2002).

With only about 25% of the technology budget remaining where is the fiscal support for professional development and instructional innovation leeway?

In summary, the factors associated with the district and school that often prove to be barriers to technology integration in the classroom include *community members* and *administrators* who may push for instructional practices that do not fall inline with research-proven methods and the *school environment* which may be lacking adequate access to technological and human resources.

The Teacher

What skills or qualities are required for teachers interested in integrating technology into their classroom? In what ways do teachers need to change their practice in order to effectively use technology?

Be it the “sage on the stage” or the “guide on the side” the teacher is undoubtedly a critical factor determining the level of success for any technology-based project. Similar to other initiatives, the teacher is the decision maker/director who has the greatest influence on classroom events. Callister and Dunne (1992) cautioned us that, “If the teacher does not know what to make of the tool, or fears it, or misconstrues its uses, it will be used badly or not at all” (p. 325).

Technology skills and proficiency. Often, the most foreseeable hurdle for teachers implementing technology into their classroom is their own lack of computer knowledge and experience. Those teachers with prior computer experience are more likely to learn new necessary skills quickly and seamlessly than those who have no prior experience. They are also more apt to use technology for instructional purposes (Hanks, 2002). Despite that, learning new computer skills requires significant amounts of time and, therefore, the importance of professional development should not be under-estimated. Effective professional development needs to provide time for training, experimentation, as well as follow-up support (Casey & Rakes, 2002; Groves et al., 1998; Levine & Donista-Schmidt, 1998). It also needs to support teachers in developing and sustaining alternative pedagogies and teaching strategies (Dede, 1997). This is where professional development often falls short in schools—addressing the new pedagogies necessary for successful implementation.

Teacher perspective. *Attitudes and beliefs*: Teacher attitudes and beliefs are powerful forces which significantly influence actions in the classroom. Teacher beliefs influence professional practice, and therefore, become pivotal factors in the implementation of new technologies (Haney & Lumpe, 1995). To implement technology successfully in their classroom, teachers must develop a positive attitude towards computers and feel comfortable using them as instructional tools (Rakes & Casey, 2002). Often, however, teachers' "attitudinal pendulum" does not swing as far to the positive side of the spectrum as most educational technologists might like and many still remain skeptical of the value of technology.

Teachers often feel apprehensive about technology because use of computers requires them to challenge their current role in the classroom (Earle, 2002; McKenzie, 2004; Zhao & Frank, 2003). When attempting a technology-based project, teachers may find themselves taking on roles they never before had to fulfill such as the role of instructional designer, trainer, collaborator, team coordinator, advisor, and monitoring/assessment specialist (McGhee & Kozma, 2003). They may also find themselves in the role of "student," as many of the classroom pupils find themselves teaching the teacher how to use aspects of technology—an uncomfortable role for many teachers (Bowman, 2004). Although many of these roles may not be foreign to the teacher, the definition of these roles in regard to technology implementation may be.

Computer-related instructional tasks require teachers to confront their pedagogical beliefs as well. Teachers who select technology-based projects that more closely align with their pedagogical beliefs are much more likely to find success (Chaptal, 2002; Zhao et al., 2002). Ogle and Byers (2000), however, indicate that effective technology-enhanced environments need to be more student-centered. This model is often in direct contrast with society's traditional view of the classroom where the teacher is the sole distributor of knowledge. As a result, for teachers to envision effective uses of computers, they must experience a paradigm shift from the teacher-centered classroom to the student-centered classroom (Adams & Burns, 1990; Bitner & Bitner, 2002; Hannafin & Savenye, 1993; Harris & Grandgenett, 1999; Mandinach & Cline, 2000). Such a shift occurs more rapidly as the amount of technology use and the teacher's technology proficiency increases. According to Becker and Ravitz (1999), changes in teaching practices and beliefs are positively correlated to the longevity of computer use in the classroom by teachers and students.

Concerns and adoption stages: Effective use of technology often requires extensive changes in classroom routines which can also produce significant levels of anxiety and concern (Bitner & Bitner, 2002). Rakes and Casey (2002) derived a model that described the *Stages of Teachers' Concerns* with respect to technology. According to this model, there is an evolution in teachers' concerns as the stages progress—concerns evolve from being negative (regarding the teachers' abilities with the innovation) into concerns that are more positive (addressing ways to enhance the innovation). According to Rakes and Casey, teachers' concerns progress towards more productive stages as experience and skill development with the innovation increases[2].

Other researchers have also tried to map teacher progression with technology implementation in the classroom. The *Stages of Instructional Evolution* (Sandholtz, Ringstaff, & Dwyer, 1997) and the *Level of Technology Implementation* (LoTI; Moersch, 1999) are two of the most prominent continuums in the literature. Both continuums acknowledge that learning to teach with technology is an evolutionary process that moves sequentially through various stages or levels of use.

Knowledge of support resources. Implementation of technology-based projects requires access to a wide range of resources, often beyond the teachers' immediate control. Knowing where to look and how to tap different types of support and resources is an important teacher quality (Zhao et al., 2002). These resources can take many forms—from human to digital: a teacher down the hall who knows the technology well, an online colleague in a forum who has expertise in particular technologies or pedagogical strategies, trouble-shooting websites that provide technical support, a weblog that focuses on the integration of technology within a particular subject area, and so on. Teachers' abilities to identify the human and digital resources, within and outside their school, that can provide the help they need, can have a dramatic impact on the success of a technology project.

In summary, teacher characteristics such as lack of *technology-based skills, attitudes and beliefs* that do not favor technology-based learning, *concerns* towards the introduction of computers, and lack of familiarity with *support resources* can prove to be barriers to technology integration in the classroom.

The Project/Innovation

What kinds of technology-based projects are more likely to succeed in schools? How can teachers decide on technology-based projects suitable for their particular context and classroom?

The qualities or characteristics of technology-based projects can significantly influence the possibilities for success (Zhao et al., 2002). Simply put, some technology-based projects are more difficult to implement than others. In particular, Zhao et al. identified two dimensions related to the project itself that could impede its success: *distance* and *dependence*.

Distance. *Distance* refers to the deviance of technology-based projects from existing instructional contexts. Each school has a culture, comprised of its value set, pedagogical beliefs, and instructional practices. Technology-based projects that are removed from the school culture are less likely to be successful. A technology-based project might also be too distant from teacher current practices and prior experiences, not only requiring new classroom pedagogy but also new roles, instructional techniques, and so forth. If the project requires the teacher to also cover new content or objectives, this increases the distance from current practice and, therefore, decreases the likelihood of success. Finally, distance from school resources is also a factor. If a project requires the acquisition and implementation of technologies that do not currently exist in the school or dominates the use of existing resources it increases the distance from success (Zhao et al., 2002).

Dependence. *Dependence* on others outside the classroom or resources can also decrease the likelihood of project success (Zhao et al., 2002). Technology-based projects with a low level of dependence on others are more likely to be successful. Similarly, projects that minimally rely on technologies outside of the educator's control can fair better (Zhao et al.). The struggles with gaining adequate access to technological resources are not foreign to teachers. Hanks (2002) and Morris (2002) found that availability and access to technologies was one of the largest determinants of *if* and *how* teachers selected to use technology in their classroom.

In summary, the project or innovation can inherently possess barriers to achieving success if it exhibits *distance* from the school context and *dependence* on resources outside of the teacher's control.

The Students

What prior student experiences, skills, and attitudes are necessary when implementing instructional projects that make use of technology? How do students respond to the classroom environment when technology is introduced?

As with any project or lesson, students affect the manner in which instruction is initiated, designed, and delivered. It is logical, therefore, to assume that the students who will be working with the technology-based project will impact the likelihood of success. Educators who fail to anticipate the potential challenges and resistance to technology-integrated projects from their students may be alarmingly discouraged by their reaction and consequently develop negative perceptions toward these types of instructional projects (Åkerlind & Trevitt, 1999). As a result, student characteristics must be taken into consideration when attempting to identify potential barriers. The background, attitudes, beliefs, and skills that students bring to a proposed project can significantly influence its direction and success.

Experience and background. Since many technology-based projects require active student involvement, students must be comfortable with this new paradigm. Technology-based projects often require students to undertake a larger workload that can also be different in nature—completing open-ended tasks, collaborating with others, directing their own learning, and assuming new leadership roles to name a few (Atkinson, 1994). These activities might be challenging for those students accustomed to more traditional environments where the teacher directs the learning process. Therefore, student experience with constructivist learning can facilitate the success of a project.

Technology proficiency. Just like teachers, students need to know how to use the technologies embedded in a project in order to achieve success. If the majority of students in a class are not proficient with the tools they will be using, appropriate training should be provided prior to the beginning of the project or get embedded in the project itself. Some technologies and software programs require an intense amount of training and for these tools this can become a project in itself.

Attitudes and beliefs. Technology-based projects are often challenging because they require students to organize and manage their progress, monitor time on task, and regulate their own learning (McGhee & Kozma, 2003). All of those tasks are minimally familiar to the majority of the student population. When presented with something unfamiliar, feelings of anxiety and concern of performance can quickly develop. Student concerns and attitudes toward an innovation can be broken down into *enjoyment* of computer use, *motivation* toward computer use, level of *importance* students assign to learning computer skills, and *anxiety* toward computer use (Liu & Johnson, 1998). These attitudinal factors can affect students in the class-room and can leave the project floundering. Åkerlind and Trevitt (1999) noted that "if we as teachers do not acknowledge the demands this can make on students, and work with them (where necessary) in enabling the transition process, we are undermining the likely educational success of the technolog-ical innovations we are introducing" (p. 98).

In summary, learners—who are the primary operators of the innovation—present their own barriers to achieving success with any technology-based project. Similar to teacher barriers, student barriers include limited *prior experiences* with technology-based projects, *technology skills,* and *attitudes and beliefs* toward computers.

Technology

What is it about technology that makes it inherently and uniquely difficult to integrate? How do these characteristics interact with classroom dynamics?

To present a complete picture of the barriers to integrating technology into the classroom, we must also discuss the difficulties inherent to computers and technologies themselves. The nearly infinite list of potential problems that the technology itself can present includes: hard drive failures, insuffi-cient memory, computer systems incompatibility with peripherals and software, misplaced, lost or corrupted files, and so on. The strongest strategy for avoiding such challenges is to work with up-to-date technologies and build a strong infrastructure that is composed of uniform computer systems and a coherent technology team. In summary, by its very nature, technology brings its own challenges and, therefore, creates its own barriers to success in the classroom.

The review of the literature that has just been presented examined the factors that influence the effective integration of technology into classroom instruction. Although our review included factors that extend well beyond the school boundaries (e.g., policy and research), we focused primarily on four factors that can be directly addressed by teachers. These factors are associated with the Context, the Innovator, the Innovation, and the Operators. In this section, we organize our findings into a framework, entitled the **i**^{5} (Figure 2, and Figures 2a and 2b, for a detailed view). The **i**^{5} can help individual teachers, as well as those working with teachers (e.g., technology coordinators, administrators, etc.) to navigate the complex process of technology integration and increase the likelihood of experiencing success with the implementation of technology innovations in their local context. By using the **i**^{5}, individual teachers can identify potential barriers to the implementation of technology-based projects in their classrooms. Identifying potential barriers upfront can empower teachers to seek solutions early in the process, thereby increasing the possibilities of experiencing success with technology integration.

The **i**^{5} was essentially designed as a means of surveying the instructional landscape in which a technology-based project will be used. It enables teachers to reflect on the likelihood of success by pointing out four possible factors that may influence the effective implementation of a technology-based project (the Context, the Innovator, the Innovation, and the Operators). Each primary factor is listed in a separate column and includes three associated variables. As a result, there are a total of 12 variables presented in the **i**^{5} that could potentially facilitate or hinder the effective implementation of technology. For example, the fourth column of the **i**^{5} looks at the Innovator's (teacher's) proficiency with technology (see Figure 2 and 2a for a detailed view). If a teacher is very familiar with all of the technologies that will be used in the proposed project, then he/she would select the bottom box (giving this variable a score of '1'). On the other hand, if a teacher has severely limited or no prior knowledge of the technologies to be used for the completion of this project, then he/she would select the top box of the fourth column (earning a score of '3'). This process would be repeated for all 12 variables. At the completion of this process, the **i**^{5} illuminates for the teacher areas that may develop to be significant barriers to the success of the project. The teacher can use this information to seek out ways to address implementation. Since the **i**^{5} has not been implemented in a real world context yet, in the following section we provide a fictitious example of how

The i⁵

An Individualized Inventory for Integrating Instructional Innovations

Project Title: ______

STEP 1: Identify the Project's Distance from Current Instructional Conditions

(Increasing Distance from Current Practice/Resources)

Level	The Context (School): Organizational Culture/Support	The Context (School): Human Infrastructure	The Context (School): Technology Infrastructure	The Innovator (Teacher): Technology Proficiency	The Innovator (Teacher): Pedagogy-Tech Proficiency	The Innovator (Teacher): Knowledge of Resources
3	Little or no peer support exists from fellow teachers through occasional collaboration and accommodation of the teacher's project in their instructional setting.	A weak or no human infrastructure exists, lacking in responsive technical staff (translators), supportive administration and/or policies on technology issues.	A weak technological infrastructure exists with little access to computer labs, little ability to acquire necessary tools, and no freedom to control the technology involved.	One or more of the technology component(s) of the project do not fall within the teacher's current abilities and understandings of technology.	The use of the innovation's components conflicts with the teacher's pedagogical beliefs. (Technology is seen as a peripheral component to instruction)	Teacher has no contact with technicians and administrators. Teacher is unaware of additional support resources to augment the project.
2	Moderate peer support exists from fellow teachers through occasional collaboration and accommodation of the teacher's project in their instructional setting.	A human infrastructure exists with moderately responsive technical staff (translators), supportive administration and/or some policies on technology issues.	A moderate technological infrastructure exists with some access to computer labs, some ability to acquire necessary tools, and little freedom to control the technology involved.	The teacher has limited proficiency with one or more of the technology component(s) of the project.	The use of the innovation's components is moderately compatible with the teacher's pedagogical beliefs.	Teacher has limited contact with technicians and administrators. Teacher is aware of the additional support resources to augment the project.
1	Strong peer support exists in the form of teams or venues in which teachers can collaborate on and accommodate the teacher's project in their instructional setting.	A strong, healthy human infrastructure exists with responsive technical staff (translators), supportive administration and policies on technology issues.	A strong technological infrastructure exists with access to computer labs, ability to acquire necessary tools, and freedom to control the technology involved.	The technology component(s) of the project falls within the teacher's current abilities and understandings of technology.	The use of the innovation's components is very compatible with the teacher's pedagogical beliefs. Teacher is able to handle the changes in classroom environment from the onset of the project.	Teacher has contact with technicians and administrators. Teacher has numerous additional support resources to augment the project.
	Rating:	Rating:	Rating:	Rating:	Rating:	Rating:

Level	The Innovation (Project): Distance from School Culture	The Innovation (Project): Distance from Resources	The Innovation (Project): Distance from Current Practice	The Operators (Students): Technology Proficiency	The Operators (Students): Project-Style Experience	The Operators (Students): Beliefs / Attitudes
3	Project deviates from school culture and pedagogical beliefs. Project is dependent on support or participation from several persons to succeed.	New technologies are required to complete the project. High level of dependence on the technology exists, as most of the technologies lie outside of the teacher's control.	Project is not derived from an existing project previously completed by the teacher and is a completely new educational experience for the teacher.	Students have no previous experience and/or abilities with the technology components of the project.	The project places the students in several new roles and/or responsibilities that the students have not already previously experienced.	Students have a negative attitude toward the innovation, expressing many concerns and anxiety toward their responsibilities for the project.
2	Project moderately deviates from school culture and pedagogical beliefs. Project has a low level of dependence of support or participation from others to succeed.	Small additions or upgrades of technology are required to complete the project. Moderate dependence on the technology exists, as the teacher has some control.	Project is similar to an existing project previously completed by the teacher, but consists of new educational experiences for the teacher.	Students have limited proficiency with one or more of the technology component(s) of the project.	The project places the students in a new role and/ or responsibilities that the students have not already previously experienced.	Students have a neutral attitude toward the innovation, expressing minimal concerns or anxiety toward their responsibilities for the project.
1	Project does not deviate from school culture and pedagogical beliefs. Project is not dependent on support or participation from others to succeed.	No new technology is required to complete the project. Little, if any, dependence on the technology exists, as the teacher has nearly full control.	Project is derived from an existing project previously completed by the teacher, or is a variation of prior educational experiences for the teacher.	The technology component(s) of the project fall within the students' current abilities and understandings of technology.	The project does not place the students in any new roles and/or responsibilities that the students have not already previously experienced.	Students have a positive attitude toward the innovation, expressing no concerns or anxiety toward their responsibilities for the project.
Total Score:	Rating:	Rating:	Rating:	Rating:	Rating:	Rating:

STEP 2: Use the Rating to Generate Support Strategies

Organizational Culture/Support	Human Infrastructure	Technology Infrastructure	Technology Proficiency (Teacher)	Pedagogy-Tech Proficiency	Knowledge of Resources	Distance from School Culture	Distance from Resources	Distance from Current Practice	Technology Proficiency (Students)	Project-Style Experience	Beliefs / Attitudes
Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:	Possible ways to address this:

Figure 2. The i⁵ (An Individualized Inventory for Integrating Instructional Innovations)

Increasing Distance from Current Practice/Resources ↑

THE CONTEXT (School)			THE INNOVATOR (Teacher)		
Little or no peer support exists from fellow teachers through occasional collaboration and accommodation of the teacher's project in their instructional setting.	A weak or no human infrastructure exists, lacking in responsive technical staff (translators), supportive administration and/or policies on technology issues.	A weak technological infrastructure exists with little access to computer labs, little ability to acquire necessary tools, and no freedom to control the technology involved.	One or more of the technology component(s) of the project do not fall within the teacher's current abilities and understandings of technology.	The use of the innovation's components conflicts with the teacher's pedagogical beliefs. (Technology is seen as a peripheral component to instruction)	Teacher has no contact with technicians and administrators. Teacher is unaware of additional support resources to augment the project.
Moderate peer support exists from fellow teachers through occasional collaboration and accommodation of the teacher's project in their instructional setting.	A human infrastructure exists with moderately responsive technical staff (translators), supportive administration and/or some policies on technology issues.	A moderate technological infrastructure exists with some access to computer labs, some ability to acquire necessary tools, and little freedom to control the technology involved.	The teacher has limited proficiency with one or more of the technology component(s) of the project.	The use of the innovation's components is moderately compatible with the teacher's pedagogical beliefs.	Teacher has limited contact with technicians and administrators. Teacher is aware of the additional support resources to augment the project.
Strong peer support exists in the form of teams or venues in which teachers can collaborate on and accommodate the teacher's project in their instructional setting.	A strong, healthy human infrastructure exists with responsive technical staff (translators), supportive administration and policies on technology issues.	A strong technological infrastructure exists with access to computer labs, ability to acquire necessary tools, and freedom to control the technology involved.	The technology component(s) of the project falls within the teacher's current abilities and understandings of technology.	The use of the innovation's components is very compatible with the teacher's pedagogical beliefs. Teacher is able to handle the changes in classroom environment from the onset of the project.	Teacher has contact with technicians and administrators. Teacher has numerous additional support resources to augment the project.
ORGANIZATIONAL CULTURE/SUPPORT	HUMAN INFRASTRUCTURE	TECHNOLOGY INFRASTRUCTURE	TECHNOLOGY PROFICIENCY	PEDAGOGY-TECH PROFICIENCY	KNOWLEDGE OF RESOURCES
RATING:	RATING:	RATING:	RATING:	RATING:	RATING:

Figure 2a.

Since the **i**[5] has not been implemented in a real world context yet, in the following section we provide a fictitious example of how we envision its use by individual teachers.

THE INNOVATION (Project)			THE OPERATORS (Students)			
Project deviates from school culture and pedagogical beliefs. Project is dependent on support or participation from several persons to succeed.	New technologies are required to complete the project. High level of dependence on the technology exists, as most of the technologies lie outside of the teacher's control.	Project is not derived from an existing project previously completed by the teacher and is a completely new educational experience for the teacher.	Students have no previous experience and/or abilities with the technology components of the project.	The project places the students in several new roles and/or responsibilities that the students have not already previously experienced.	Students have a negative attitude toward the innovation, expressing many concerns and anxiety toward their responsibilities for the project.	3
Project moderately deviates from school culture and pedagogical beliefs. Project has a low level of dependence of support or participation from others to succeed.	Small additions or upgrades of technology are required to complete the project. Moderate dependence on the technology exists, as the teacher has some control.	Project is similar to an existing project previously completed by the teacher, but consists of new educational experiences for the teacher.	Students have limited proficiency with one or more of the technology component(s) of the project.	The project places the students in a new role and/ or responsibilities that the students have not already previously experienced.	Students have a neutral attitude toward the innovation, expressing minimal concerns or anxiety toward their responsibilities for the project.	2
Project does not deviate from school culture and pedagogical beliefs. Project is not dependent on support or participation from others to succeed.	No new technology is required to complete the project. Little, if any, dependence on the technology exists, as the teacher has nearly full control.	Project is derived from an existing project previously completed by the teacher, or is a variation of prior educational experiences for the teacher.	The technology component(s) of the project fall within the students' current abilities and understandings of technology.	The project does not place the students in any new roles and/or responsibilities that the students have not already previously experienced.	Students have a positive attitude toward the innovation, expressing no concerns or anxiety toward their responsibilities for the project.	1
DISTANCE FROM SCHOOL CULTURE	DISTANCE FROM RESOURCES	DISTANCE FROM CURRENT PRACTICE	TECHNOLOGY PROFICIENCY	PROJECT-STYLE EXPERIENCE	BELIEFS / ATTITUDES	Total Score:
RATING:	RATING:	RATING:	RATING:	RATING:	RATING:	

Figure 2b.

The i⁵ in Context: A Possible Example

The following fictitious vignette portrays an example of how an individual teacher can use the **i⁵** *to determine the likelihood of success of a technology-based project in his existing context and the ways in which he can address emerging challenges identified by the* **i⁵** (see Figures 3a and 3b).

Mr. K, a seventh grade teacher, has decided to take his tried-and-true "American Presidency Research Unit" and adapt it to fit some of the new technologies in his school. Ms. Q, the district's technology coordinator, recently installed the web-editing software Dreamweaver on all classroom computers. Mr. K decided to change his project from just asking students to convey their research by way of a booklet or research paper, to one where students must communicate their findings through a more dynamic medium such as a website. Mr. K's goal is for his students to gain valuable technology skills, as well as understand other implications related to 21st century modes of communication (e.g., communicating information to a larger audience, communicating ideas using multiple media, etc.). Mr. K has noticed the increased technology skills of his students and believed that they would really do well with this new task. However, Mr. K realized that developing a website would be a time consuming task and, therefore, decided to initiate some group work. He thought that group work would not only expedite the completion of the project but would also help students develop valuable collaboration skills. Although Mr. K was eager to make these alterations, he was not very sure as to how to proceed with the project—he had only three computers in his classroom and he did not have working knowledge of the school's web-building application, Dreamweaver.

Fortunately, Ms. Q is very supportive and helpful whenever she can make herself available. Mr. K is very grateful of Ms. Q's support since technology has typically not been viewed as an important tool at his school. Ms. Q's support certainly helps Mr. K feel more confident about his chances of success, but he still has not figured out the logistics of completing the project. Ms. Q encourages Mr. K to take a few minutes and complete the **i^5** to determine his likely success with this project as well as identify potential hurdles (see Figures 3a and 3b for Mr. K's scoring rationale).

After completing the **i^5** for this potential project, Mr. K examines the results carefully to identify potential barriers and address them prior to the beginning of the project. He starts with the "red flags," or the areas which received a score of "3" on the **i^5**. Fortunately for Mr. K, he only has this score in two of the 12 variables presented in the **i^5**. The first "3" to overcome lies in his own lack of familiarity with Dreamweaver. Ms. Q reminds him that there is an upcoming professional development opportunity on Dreamweaver in the next few weeks. Mr. K signs up for the course. The other "3" is the insufficient technological infrastructure at the school. Mr. K realizes that managing his students to complete the project with only three computers in the classroom will be difficult. It takes some work but he arranges a schedule where the students have access to the school's computer lab three times during the week.

At this point, Mr. K is feeling good that he has addressed two major issues to having success with this project. To further increase the likelihood of success, Mr. K attempts to address some of the areas in which he received a score of "2". He realizes that some may be out of his immediate range for the moment—such as the lack of peer support and human infrastructure at his school—but nonetheless helpful to be cognizant of before beginning the project. As an effort to compensate for these challenges, he makes time to meet with Mrs. R who has been using Dreamweaver in her classroom for a variety of projects. He also uncovers a weblog of other educators using Dreamweaver as an instructional tool. He feels that these resources will help him learn how to manage a technology-based project like the one proposed, something he has not encountered before. The last "2s" that Mr. K feels are important to address are those related to his students. Aware that many of his students have not used Dreamweaver before, he arranges a class period to be devoted to learning its basics, graciously taught by Ms. Q. He also wants to capitalize on his students who are familiar with Dreamweaver to help coach others who are not. He knows, however, that this is a role new to his students. Mr. K conducts some research on peer-mentoring and uncovers some strategies to help his students undertake this new role.

After taking care of the preparation work, Mr. K feels ready to take on this project, armed with strategies and supports to help him overcome the likely obstacles identified in the $\mathbf{i^5}$.

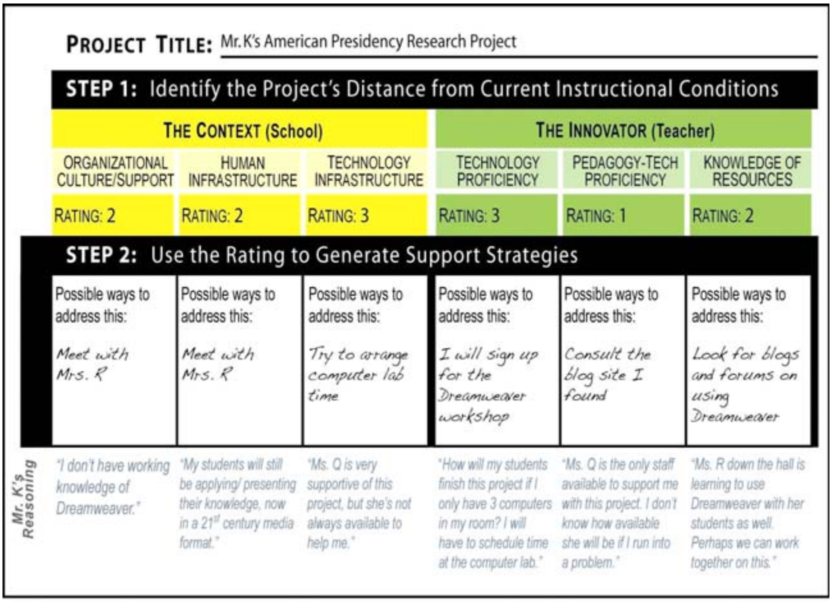

Figure 3a. Example use of the **i**[5] (part 1)

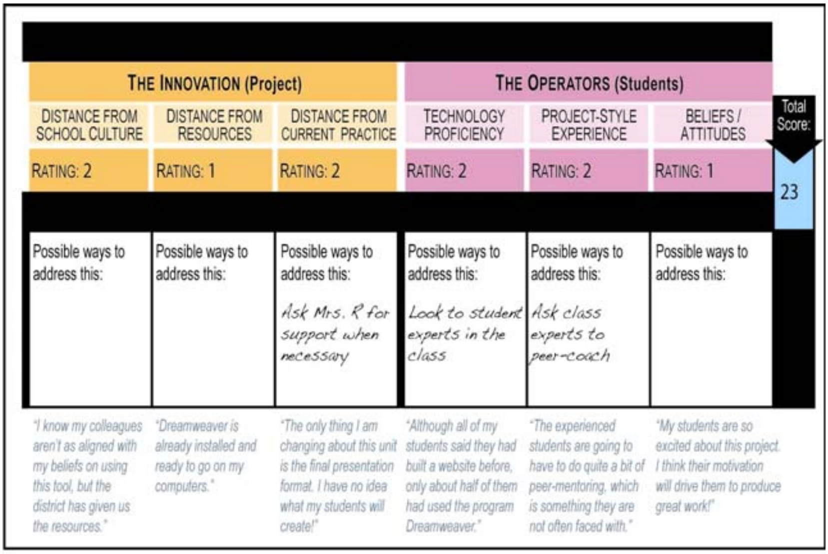

Figure 3b. Example use of the **i**[5] (part 2)

CONCLUSION

Using technology in the classroom is a complex, challenging task. This is evident by the lack of progress in technology integration in K-12 schools in this country, considering the length of time that has passed since the first computers made their appearance in the instructional setting. The obstacles to successfully completing a technology-based project in the classroom are vast and diverse in nature. They include:

- lack of concrete research and consensus among experts on the objectives and outcomes of technology integration into the school curriculum;
- assorted hardware and software available for school selection with unclear support on which meet a school's needs;
- lack of teacher input on the development of innovations for instructional use;
- pressure and insufficient support (in the form of resources, time, professional development, and human and technological infrastructure) from the administration, community, and policy-makers to use the technology;
- inadequate school culture necessary to cultivate technology-based project success;
- teacher beliefs, attitudes, and concerns about classroom technology use—inexperience with technology, the shift of pedagogical practices, management issues, and the possibility of new roles and teaching style;
- challenges associated with technology-based projects (including its alignment with school culture/goals, compatibility with existing resources, and alignment with prior teacher experiences);
- student attitudes, concerns, and experience with technology in general and as an instructional tool, as well as background in the new roles associated with student-centered projects; and
- problems inherent to technology and computers themselves (such as unreliability).

By synthesizing the challenges to effective technology integration as identified in the research literature, we have developed a framework, called the **i**^{5}, that can help teachers successfully implement technology-based projects in their classrooms. Although the **i**^{5} was founded largely on the knowledge created from empirical research, it has not yet been formally tested in an instructional setting. Our next step will be to test the **i**^{5} in real classroom settings. We are interested in investigating the **i**^{5}'s ability to accurately predict project success, as well as illuminate and head-off potential obstacles to a technology-based project.

The goal for all teachers should be to create highly effective classroom environments that can meet 21st century skills and demands. Technology can be a powerful resource to achieve this goal and tools like the **i**^{5} can help all teachers successfully integrate technology in their classrooms.

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Notes

1. To be sure, The No Child Left Behind legislation requires schools to ensure that every student is technologically literate by the time he/she finishes the eighth grade. The emphasis, however, is on technology skills rather than an understanding of how to use the technology in the learning process.

2. To be accurate, the work of Rakes and Casey (2002) is based on the *Concerns Based Adoption Model* first developed by Hall, Wallace, and Dosset (1973).