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ABSTRACT

This position paper presents the STAIRS model for overcoming barriers to teachers as they implement and integrate instructional technology in science classrooms. There are many barriers for teachers in the integration of this technology which include time to learn how to use the technology, adequate hands-on staff development opportunities, support for release time and funding for professional development, adequate teacher empowerment for technology planning, and adequate recognition for teachers who engage in the extra effort to integrate instructional technology. The STAIRS model presents a plan of action to overcome these barriers. The model adopts an integrated approach to the successful sustained implementation of technology as teachers' strategies shift to an increased emphasis on student-centered learning in a multi-sensory environment. The STAIRS model paves the way for this increased emphasis by developing a technologically-rich environment for students as they learn in an authentic, real-world context. (Contains 25 references.) (WRM)

A Model for the Successful Implementation of Instructional Technology in Science Education

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Abstract

This position paper presents the ST^{4}AIRS model for overcoming barriers to teachers as they implement and integrate instructional technology in science classrooms. There are many barriers for teachers in the integration of this technology. They include; time to learn how to use technology, adequate hands-on staff development opportunities, support for release time and funding for staff development, adequate teacher empowerment for technology planning, and adequate recognition for those teachers who engage in the extra effort to integrate instructional technology. The ST^{4}AIRS model presents a plan of action to overcome these barriers. The steps in this model include; support for teachers, time for staff development, trainers that are qualified teachers who train other teachers, transition time for planning and integration, access to hardware and software, involvement in planning and integration, recognition for teachers, and adequate staff development that integrates all steps in the stairs. This model presents an integrated approach to the successful sustained implementation of technology, as teachers' strategies shift to an increased emphasis on student-centered learning in a multi-sensory environment. This model paves the way for this increased emphasis by developing a technological rich environment for students as they learn in an authentic, real-world context.

Introduction

Although teachers now have the advantage of unprecedented amount of technology for their classrooms and schools, we find, paradoxically, little evidence to indicate that teachers systematically integrate instructional technology into their classroom curriculum. It is not surprising to find that only about five percent of instructional technology programs succeed or endure beyond a three- to five-year period. Several factors erode efforts a school district might make to sustain an effective program. A focus on hardware rather than on processes, a weak planning process that fails to meet the needs of teaching and learning, and little or no staff development contribute to thid erosion of efforts (Eastwood, Harmony, & Chamberlain, 1998).

The use of instructional technology in schools is a fact of life in American education. For students, the ability to use instructional technology has been recognized as an essential skill. Recognizing their responsibility to prepare students to work and live in a technological society, states and school districts have adopted standards for teaching students with and about technology. Also, the International Society for Technology in

Education's *National Education Technology Standards for Students* (1998), National Research Council's *National Science Education Standards* (1996), and National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* (1989) that emphasize the use of technology in the curriculum. These standards advocate instructional technology methods that encourage students to become active participants in the learning process while using the methodology employed by professional mathematicians and scientists. For example, using a computer or calculator to collect and organize large sets of data, view graphs of complex relationships, etc. (Bowman & Davis, 1997).

To use technology well; teachers need to know how to use technology, they need opportunities to discover what the technology can do, learn how it operates, and methods for integrating it in their curriculum. To accomplish this, teachers must be technology literate and technically comfortable in the use of technology. However, the process of adopting new technologies has never been quick or effortless in education. Like all professionals; teachers have instructional methods, teaching styles, and working procedures. And like other large institutions, schools have organizational characteristics that make change difficult. The unique culture of schools and changing public expectations for them create conditions substantially different from those of other work places (U.S. Congress, Office of Technology Assessment, 1995). This is a natural result of the educational environment that teachers work. Teachers brought up in this environment of lecture followed by paper-and pencil drill or cookbook lab exercise, find it difficult to shift paradigms. On the positive side, teachers as a whole want to employ all available resources to help their students learn, including the use of technology. As instructional technology and improvements in technology become more sophisticated, the transition has become even more difficult and requires more staff development for teachers. This is not easy, because teachers often find themselves bewildered by ever-changing applications of technology. Based on his research, Rubba (1991) argues that teachers with little or no background and experience in technology cannot be expected to successfully implement technology in science. It is very difficult for science educators to overcome their organizational culture do devise and implement the integration technology without support.

To understand the problems and what changes need to be made to successfully implement instructional technology, this paper will address the issues. First, common barriers for teachers in the implementation of technology in their classroom will be discussed. Second, approaches for overcoming these barriers. Followed with the ST^4AIRS model that will provide a method of overcoming these barriers to allow teachers to implement technology into the classroom.

Common Barriers

There are a number of common barriers to teachers using instructional technology. These common barriers include (Dexter, Anderson, & Becker, 1999; Becker, 1991; U.S. Congress, Office of Technology Assessment, 1995; Ritchie, 1996):

- Teachers need time to experiment with technology and share their experiences with other teachers. They need to be given the time to attend workshops and other inservices to provide them with the basic core of knowledge. This allows them to better understand technology basics. To effectively use technology, they need official planning time to adequately integrate this technology into their lesson plans. This is probably the greatest barrier to technology use in the classroom.

- Funding is a barrier to adequate implementation. Hardware, software, and staff development costs can be expensive. But these expenses are necessary to successfully implement any type of technology.

- Access is another barrier that teachers need to learn to be technologically comfortable and literate. Many schools do not locate technology tools in the most accessible places. Equipment may be contained in central labs that teachers need to reserve well in advance. The equipment may be located in one teacher's classroom or in the control of another department.

- Training and support in school districts is less than adequate as they spend less than 15 percent of their technology budgets on training, with the balance spent on hardware and software. This leaves little opportunity for teachers to have planning time or professional growth experiences. Nor are they provided with adequate technical support. Most technology initiatives are top-down. Many teachers want to use technology, but administrators who make the decisions for them do not adequately consider their needs (Technology and Learning, May 1998). Only six percent of elementary and three percent of secondary schools have full-time, school–level technology resource support. This is compounded by the fact that if quality training were provided to 10,000 teachers per year (to learn to be facilitators of information through the use of technology), it would take 250 years to reach all teachers (Joseph, J. H., 1995).

- Vision or rationale many schools do not have adequate and clear curricular goals for the use of technology. Teachers are not provided with satisfactory models showing the value of technology within their curriculum. Many school districts do not have a clear and concise, if any, technology training plan. School systems are in a dilemma because they sometimes become frustrated by the failure of instructional technology materials to easily align with text and approved curricula. The overall lack of vision and clarity of goals with regard to the role of technology in school is confusing to teachers and frustrating to administrators. This results in teachers unwilling to fully commit themselves to ever changing goals and programs (O'Neil, 1995).

- Assessment practices include existing standardized measurements of student achievement that do not adequately reflect integration of technology.

Compounded by practice of teachers being held immediately accountable for changes that take time to show results of the benefit of technology integration.

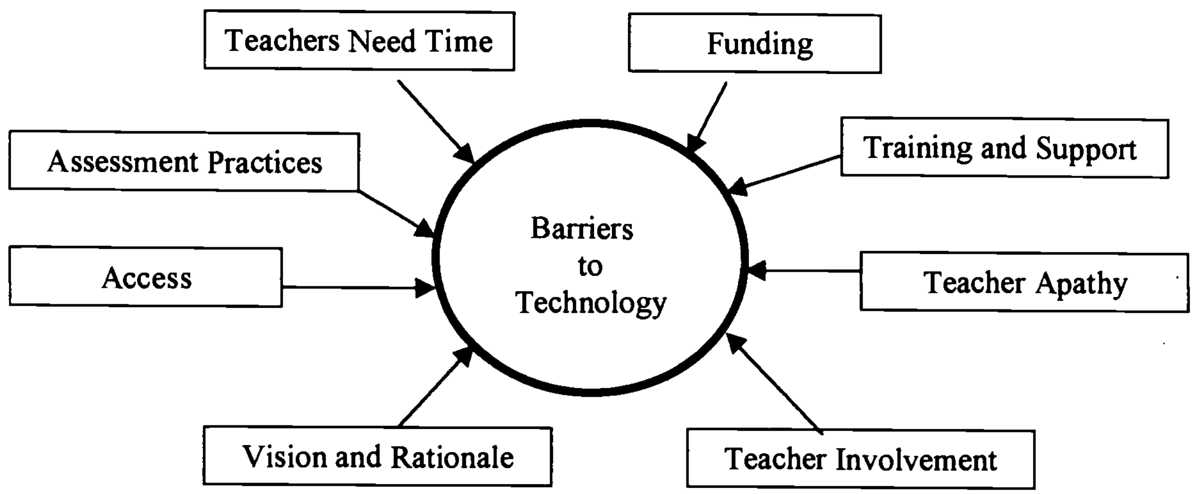
- Teacher involvement in the planning process. Teachers are not thoroughly involved the process of integration and lack the sense of ownership or personal commitment to integration of technology.

The previous data focused on factors that are not within the teacher's control, yet teacher attitude has a controlling influence as a barrier to the sustained integration of technology. I have interviewed many teachers concerning their view of using technology in their classroom. Their views range from full support for using technology, including those who would use technology if they were given time for training. To the opposite end of the continuum, by indicating that there could be a use for it, if they believed the use of any technology. In a statement on Educational Technology in the 21st Century before the House Committee on Science, Space, and Technology, Jeffrey H. Joseph (1995) stated that only 36 percent of teachers indicate a newly-found willingness to change what they do and incorporate technology into their daily lesson plans. The pedagogical beliefs and practices a teacher holds may influence whether he or she will use technology (Cuban, 1986). For example, one study found that *high-tech* teachers tended to hold more of a student-centered approach to teaching (hands-on, inquiry methods, collaborative practices, etc.) and used technology in their classroom. While *low-tech* teachers were more diverse: using a mix of inquiry methods, student-centered learning, or traditional learning because they feared technology would undermine their authority in the classroom (Honey & Moeller, 1990).

Of all the barriers to the use of technology (see Figure 1), lack of teacher time is the greatest. There are many demands on a teacher during the course of a school day, with little or no time allotted to explore the technology, talk with other teachers to discuss applications of this technology, and integration of the technology into curricula. Unless there are significant changes to the school routine to provide more time for teachers to learn and explore technology, this barrier will remain the most difficult to overcome. As in any profession, time must be invested in learning how to use a particular piece of software or hardware. Teachers, in particular, are prisoners of time as a national study recently underscored (National Commission on Time and Learning, 1994). American schools require teachers to spend the vast majority of their school time actually engaged in instruction. Very little school time is allotted for planning, preparation, or learning new things. Even technology proficient teachers rated the lack of time as among the most problematic barriers to using technology in school (Sheingold & Hadley, 1990).

Figure 1:

Common Barriers to Teachers using Technology



Overcoming the Barriers

The challenge of integrating instructional technology into schools and classrooms is much more human than it is technologically. It is not only about helping teachers to learn how to operate technological tools; it is helping them to learn how to integrate the use of technology into their curriculum. To effectively integrate the use of technology, there are several approaches that will ease the integration. These approaches include: training master teachers to train others, providing expert resource assistance, providing adequate training for teachers, training administrators, and establishing technology training centers within the school districts.

The following are lessons that have been learned about the integration of technology into the curriculum (adapted from U. S. Congress, Office of Technology Assessment, 1995; Ritchie, 1996):

- Rationale should be accomplished by developing a clear and concise definition of goals and uses of technology. Along with including teachers in the process, which is key to successful implementation.

- Human resources for training, maintenance, technical support and time for teachers to learn how to integrate technology into their curriculum. There needs to be a full time technology resource teacher in a school to assist teachers when questions arise. The business community has technical resource personnel on staff because they need technical questions and problems answered as soon as possible, not some unknown time in the future. When a teacher has difficulty using technology, they are not in the position to stop teaching to wait for assistance; they need assistance quickly just like the business community.

- Support teachers need the support from their principals and other school administrators in fostering the sustained use of this technology.

- Training needs to be *hands-on* and based on the needs of the teachers being trained. This fosters their support as they gain confidence and competence, before using this technology in the classroom. This is essential to allow teachers the opportunity to change their teaching styles or allow those already comfortable to explore beyond their current knowledge and assist others. Also, they need to be trained on systems comparable to the ones that they will be using in their classroom. The trainer/teacher/equipment ratios must be small enough to allow for maximum hands-on learning through coaching and reinforcement.

- Access to equipment is essential for long term motivation in fully developing skills that teachers learned in workshops or other training environments. One way is to develop a cart system that can be easily moved about the school. This will help lessen the tradition of central labs and equipment permanently residing in one classroom. Quick and easy access allows teachers the opportunity for exploration and utilization in the classroom.

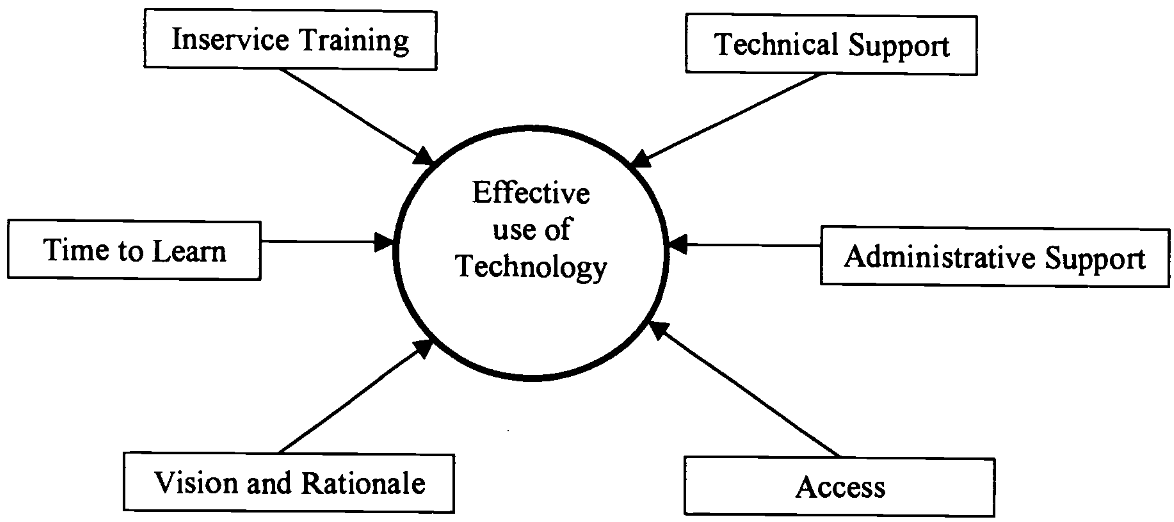
- Follow-up support is critical for long term systemic change for the integration of technology. Teachers will not learn how to effectively use this technology in a one-shot training session or workshop. Teachers always, as do others, have need for technical support or other questions following a training session. If they are trained and sent back to the isolation of their classrooms the result will not be a permanent change, especially if frustration exceeds success. There must be readily available resources to answer their questions as they arise.

Although there are many solutions to the problem of instructional technology integration into curricula, the best solutions appear to be in the training and support for teachers, along with support by administrators in the school system. Technology takes time to master. Pina (1993), states that it takes approximately 30 hours of hands-on exposure to a new technology for teachers to overcome the anxiety and create significant change in teachers' integration of technology. Hardware and software, no matter how "user-friendly' require time to master. As in any profession, time must be invested in learning how to use a system before real integration into the curriculum can occur.

Figure 2, adapted from U.S. Congress, Office of Technology Assessment (1995) illustrates the requirements for effective use of technology.

Figure 2.

Requirements for Effective use of Technology



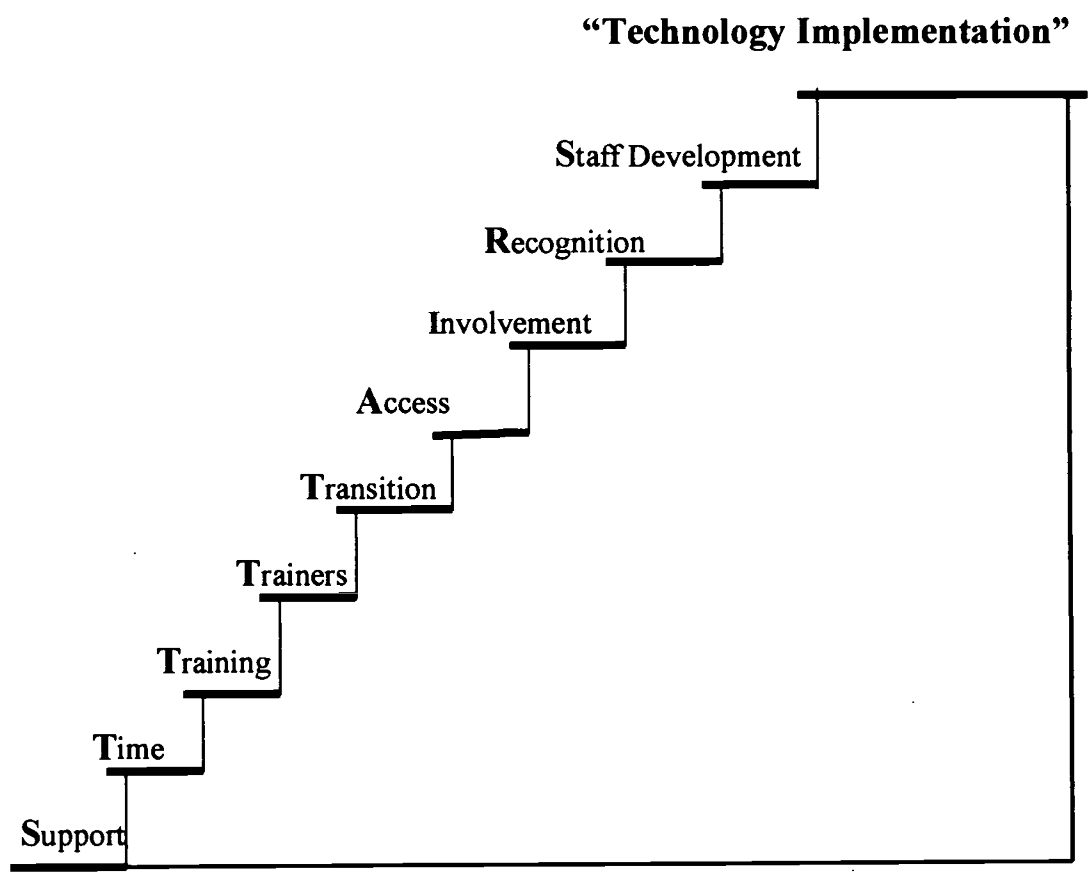
A Model for Implementation

Helping teachers gain confidence and learn to integrate technology in their classrooms is a slow process and requires school administrators to recognize that they must allow teachers the time to explore this technology. Mecklenburger (1989) indicated, when integrating technology into the classroom change is a people success, not a strictly a technological success. Successful transition occurs when administrators share the vision, exemplify the change through example, support, and empower their teachers to integrate technology in their curriculum. When schools acquire any technology they must also provide vigorous well-defined staff development (Shelton & Jones, 1996).

I have developed a model that I recommend for implementing the necessary change to overcome the barriers to successful integration of technology in the curriculum. The name of this model is "*ST^{4}AIRS*." ST^{4}AIRS refers to the need to assist teachers in climbing over the barriers through support, time, training, trainers, transition, access, involvement, and recognition through staff development for the successful implementation of technology in science education. Although this model is for technology, it is easily adapted to any technology implementation program. Figure 3 illustrates the ST^{4}AIRS model:

Figure 3:

ST^{4}AIRS Model



This model illustrates the fact that all steps in the stairs rely on each other to be successful and can not stand alone, as with any staircase. The commitment and support of all those involved in this model will achieve the ultimate goal of technology integration. This in turn improves their students' achievement and preparation for the technological world. As well as, supporting the national standards in technology and science. The following is an explanation of the ST^4AIRS model:

Support is provided by district office personnel, administrators, and the community. The district office supports the implementation of technology by establishing a policy that places staff development in technology as a priority within the district. As a minimum:

- District offices set forth a technology training plan that establishes a policy for designated training times and days, provides teachers with release time, stipends, organizes workshops, and organizes a district wide pool of qualified teachers that are trainers.

- School administrators identify a pool of qualified teachers to provide training to math and science teachers, organize workshops, provides staff development periods, establish a program that permits free access to hardware and software, and recognizes teachers for their efforts.

- Community support from businesses and parents to purchase hardware and software, coverage for teachers during release time for training, and recognition of teachers for their efforts in learning how to use and integrate this technology in their classroom.

- A pool of trainers provides support to teachers through technical assistance and are readily available for questions that need to be answered after workshops and staff development.

- A district newsletter that has a main focus of providing teachers with tips and strategies for implementing and using technology.

Time is what teachers need the most. The teaching profession is the only professional field that does not provide adequate official training time for its work force. Teachers are expected to attend workshops or staff development time after the workday and on weekends, usually without being paid for their time. Many attend workshops during the summer at their own expense. This makes it difficult for teachers to buy into the integration of any technology. What teachers need is time to attend workshops, staff development, explore applications within their curriculum, and time to build confidence in the use of the technology. To solve the time problem:

- Teachers need the dedicated staff development days and release time. School administrators spend the summer months preparing for the next school year and getting paid in the process. Yet teachers are expected to do the same over the summer months without pay. The ideal solution is to bring teachers back a few weeks before school begins and spend this time in workshops and staff development days. This facilitates working with and planning for the integration of technology. Although this is ideal, a compromise within each school district is obtainable with the support of district and school administrators.

- Teachers need time to explore how the hardware and software works. Normally workshops and staff development time is spent introducing new things to teachers. To be truly successful and allow for an efficient integration of technology teachers need time to reflect on what they have learned in a workshop and determine applications within their curriculum. Follow up sessions allows teachers to share their ideas and experiences with others, along with exploring new ideas.

- Confidence comes with self and group exploration of how to use hardware and software. Along with the generation of ideas for integrating technology into curriculum and lesson plans. Teachers need planning time to build that confidence.

Training should always be hands-on when working with technology. Teachers, anyone else for that matter, need to actually use the equipment that they use in their classrooms. Training must include these as a minimum to facilitate successful integration and teachers buying into the integration of technology:

- Training should not be a one-shot-deal. For training to be effective and bring about the desired change it should be followed with more training. This follow-up training is conducted as group sessions where teachers share what they have tried in lessons and what worked or did not work. It gives them the chance to ask those questions that surface as a result of their own exploratory experiences.

- Hands-on workshops and staff development training allow teachers to build confidence and explore the operation of technology.

- Training conducted by educators who have the classroom experience to relate to teachers and have an appreciation of a teacher's daily routine.

- Curriculum integration ideas presented to teachers who are inexperienced with technology.

- Modeling of assessment ideas and strategies.

- Modeling of inquiry-based integration strategies using technology. Incentives for attending training outside the normal workday. Such as stipends, hardware and software gifts (for example: graphing calculators and probeware sensors are a relatively inexpensive investment for the long-term return on investment), and recognition for attending. Incentives can be organized through business partners and companies that produce the hardware and software.

Trainers should be those teachers who have successfully completed appropriate workshops and staff development sessions. They have proven their ability to train other teachers through facilitating workshops or staff development sessions. They have been certified as technology trainers. They receive appropriate recognition for their accomplishment through community newspapers and staff newsletters. A further step is to certify these trainers as master trainers as recognition for their effort.

Transition is an essential time given to teachers to allow them to explore the hardware and software that they were introduced to in a workshop or staff development session. A common misconception is that teachers can immediately integrate the technology that they were exposed to in a training session. Like any good professional, a teacher needs time to explore how technology can be integrated into their curriculum and lesson plans. They need time to follow explore the capabilities and limitations of the hardware and software to build confidence. This transition time may take a full year or more and is only effective when combined with follow-up sessions with other teachers and trainers.

Access is as essential as the other steps in the stairs. Teachers need access to the hardware if they are to take advantage of the all the investment in teachers' time and funding hardware and software. Too often hardware resides in the hands of one teacher or in one place that does not allow easy access for all teachers, such as a computer laboratory. Since hardware and software is easily integrated into science, a central location is may not be ideal. Distribution of the technology into teacher classrooms is the best method, not locked up in isolated labs. When funds are limited, then one or two class sets may be possible depending on the type of technology.

Involvement is when teachers are empowered to determine the best way to integrate technology into their curriculum. Involvement of teachers occurs through the venue of curriculum development teams and participation in technology planning committees. When teachers observe they have a voice and are allowed to adapt the technology to their curriculum, then they readily buy into the use of technology. With the time to explore technology and understand how it works, they are in the best position to determine how it can be integrated into their curriculum. All to often technology training is provided by vendors who do not have a fully understand instructional techniques and practices. When teachers become trainers of other teachers, those attending the training become more involved because they relate to each other's experiences. Once teachers observe that their input is valued, the integration of technology is one step closer to a long-term success.

Recognition is one of the most important steps in the stairs. Teachers are human and like to be recognized for their accomplishments just like everyone else. Schools expend a great deal of effort to recognize students and usually come up short when recognizing teachers. Of course there are schools that recognition of teachers is considered essential, just like the students. But this is not true for all schools and needs some attention. Recognition is like worth its weight in gold to teachers who go that extra effort to learn how to use technology, attending workshops or staff development after working hours, being certified as a trainer for technology, and other instances. For those teachers who need that little extra incentive, recognition is usually all that is needed. Because this lets them know that this is important to the administration and their efforts are appreciated. The following are examples of recognition that work:

- Certificates for completing training
- Personal notes from administrators
- Recognition of achievement at staff meetings
- Recognition in a teachers corner of the school newspaper
- Articles in the education section of the local newspaper
- Recognition in the school district newsletter
- Business partner recognition for achievement as a technology trainer, especially if the business partner is in a technology field

And others that are tailored to the community and school environment.

Staff development is an integration of all the previous steps in the stairs and best summarized by Loucks-Horsley, et el. (1987):

- Collaboration with all those involved in the process
- Experimentation and risk taking
- Time to work on development and assimilation of new ideas
- Leadership through sustained administrative support
- Appropriate incentive and rewards
- Integration of individual goals with district and school goals
- Formal placement of the program within the philosophy and organizational structure of the school and district

Summary

The ST^4AIRS model is based on empowering teachers through their involvement in the planning of appropriate staff development, time to integrate what they have learned into their curriculum, administrative support, and recognition. All of which allow teachers to buy into the use of technology, which is essential for a successful long-term integration of this technology. Administrators and the community must be supportive of teachers as they learn new methodologies and strategies over a transition period. This transition period is used to provide that cushion of time between introduction of the technology and teacher confidence in using this technology. This implementation time will achieve the ultimate goal of sustainable integration of technology in the classroom to increase student understanding of science concepts as they are prepared to enter a technological world. The ST^4AIRS model provides the framework for long-term systemic change in the integration of technology in science. This model fits within the framework of 1993 National Association Science, Technology and Society Position Papers Committee presented by Daugs (1992), who stated that "Technology and integration: Experience should involve appropriate technology process and products. Technology should be viewed as a tool for expanding human potential."

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