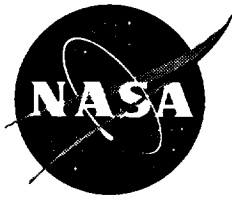


NASA/TM-1998-206547



Web-Based Instruction and Learning: Analysis and Needs Assessment

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Prepared For
NASA Dryden Flight Research Center
Edwards, California
Under NASA Research
Grant NAG 4-113 and
Contract NAS 4-50066

National Aeronautics and
Space Administration

Dryden Flight Research Center
Edwards, California 93523-0273

May 1998

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EXECUTIVE SUMMARY

In a collaborative effort between the Pennsylvania State University and the NASA Dryden Flight Research Center, a team of researchers conducted a needs assessment to identify K–12 teacher needs with regard to using the World Wide Web (WWW) for instruction and to identify the obstacles those teachers face in utilizing the NASA Learning Technologies products in the classroom. The needs assessment was conducted in three phases examining school context, curriculum content and WWW resources, and teaching and learning processes. Eight factors along with their defining dimensions were analyzed by searching online and offline references and resources, conducting online and offline interviews with school personnel, attending conferences, and reviewing national statistics on technology use in the schools.

Conclusions were drawn about the realities of the three areas of investigation: school context, curriculum content and WWW resources, and the teaching and learning processes. In the area of school context, the team has determined that while teachers are motivated to learn about the WWW and how it can be used in their classroom, they are faced with major challenges. These challenges can be categorized into four areas: 1) access, 2) skill, 3) perception and 4) time. 1) Some teachers have no or limited access to the Internet, or have outdated computers that are slow. 2) The teachers in this investigation have a limited understanding of what resources exist on the WWW, have inefficient search strategies for finding useful information, or lack skill in preparing effective Web-based lessons for their classroom. 3) Teachers also possess an impression that the best use of the WWW is to have their students create material to be published there. In this context, a fear arises that it will take a great deal of time to learn and to use the WWW, or that the computers will break down in the middle of their lessons and they will not be able to fix them. 4) A teacher's day is already full, and to add "technology" on top of it is unrealistic for most.

In the area of curriculum content and WWW resources, the team has concluded that resources from the WWW need to be able to support a process-based curriculum that follows the National Education Standards for Math and Science. The reality is that while the resources are varied in terms of type and quality, few are linked to school applications. Finding relevant resources becomes a major challenge for teachers.

In the area of teaching and learning processes, the team summarized their findings in three areas: classroom practices, Web practices, and Instruction about the Web. The reality of the classroom is that it is changing from a teacher-centered to a learner-centered environment in which children are active participants in the learning process. The resources from the WWW can be used with a myriad of teaching and learning strategies, not just as an information resource that would be useful in a teacher-centered classroom. Most of what exists on WWW instruction for teachers is to teach them about the WWW and how to develop for the WWW, leaving a need for instruction about strategies for how the WWW and all its resources can be used in the classroom.

From this analysis, four major needs were identified:

- (1) Teachers need to learn how to manage the WWW in their classroom. This must be done in a manner that does not take a great deal of additional time.
- (2) Classroom strategies of WWW use need to be developed that exemplify good teaching practice. These strategies must be simple to use and incorporate the variety of WWW resources that provide access to individuals and information.
- (3) Administrators need to learn about the WWW as well. This knowledge will result in a recognition of the advantages in WWW use, and provide teachers with appropriate access, technical support, training, and time for learning about this new classroom resource.
- (4) WWW developers need to fit their material into classroom teaching models. These models must consider access, type of WWW resources, and teaching and learning styles. Developers must also specify several options for teachers that enable them to use their materials given the realities of the classroom environment, content, and teaching practice.

PREFACE

The purpose of the needs assessment was to identify our K–14 customers' needs with regard to using the World Wide Web (WWW) for instruction and to identify the obstacles K–14 teachers face in utilizing NASA Learning Technologies products in the classroom. As our understanding of our customers' needs becomes clearer, it then becomes possible to define strategies to assist K–14 teachers to effectively use web-based NASA (and non-NASA) materials.

The investigation was conducted in three phases analyzing school context, curriculum content, and the teaching and learning processes. The areas investigated included administrative infrastructure, technology infrastructure, teacher factors, school curriculum, existing NASA web-based materials, best practices using the WWW in the classroom, teacher tutorials, and teaching and learning theories and teaching practices.

Despite the research emphasis on instructional strategies for the World Wide Web, the researchers are not proposing that the WWW be used instead of, but in addition to, other effective media and teaching strategies that have stood the test of time. Well written textbooks, stimulating lectures, group projects in which students build or study something collaboratively belong in the effective teacher's repertoire and in the learning experiences of children and youth.

The need to understand the instructional role of the WWW is related not only to its potential power as a learning tool, but to the fact that this medium is rapidly becoming an integral part of the global economy in which future generations will have to compete. We are obliged as teachers and developers to increase the scientific and technical literacy of the young to prepare them for the future.

Marianne McCarthy, Ph.D.
Learning Technologies Project Manager
NASA Dryden Flight Research Center

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Industry Contributor:

Rebecca Beaty – Science Applications International Corporation (SAIC), Los Angeles, California

Project Sponsor:

E. Lee Duke – Chief of Public Affairs, Commercialization, and Education, NASA Dryden Flight Research Center,
Edwards, California

The project team selected to conduct this needs assessment provided a multidimensional review of Web-based teaching in the classroom. The following matrix summarizes their expertise.

| Team Members | Teaching | | | Instructional Design | NASA Education Programs | Science | Publishing | Learning | Computer Science | Web Technology | School Administration |
|------------------------|----------|-----|------|----------------------|-------------------------|---------|------------|----------|------------------|----------------|-----------------------|
| | K-4 | 5-8 | 9-12 | | | | | | | | |
| Dr. Marianne McCarthy | X | X | X | | X | | | X | | X | X |
| Dr. Barbara Grabowski | X | X | | X | | | | X | | X | |
| Tiffany A. Koszalka | | | | X | | | | X | | X | |
| Angel Hernandez | | | | X | | | | | X | X | |
| Connie Garrett | | | | X | | | | X | | | |
| Leah Iwinski | X | X | | X | | | | X | | | |
| Tom Iwinski | | | | X | | | | | | X | |
| Ellen Kendall | | | X | X | | X | | X | X | | |
| Chih-Lung Lin | | | | X | | | | | X | X | |
| Jim Lloyd | | | | X | | | X | | | | |
| Natalie Tiracorda | | X | | | | X | | X | | | |
| Felipe Vazquez | X | | | | | | | | | | |
| Dr. Marchelle Canright | X | X | X | X | X | | | | | X | |
| Jeff S. Ehmen | | | | | X | | | | | X | |
| Rebecca Beaty | | | | | X | | | | X | X | |
| E. Lee Duke | | | | | X | X | | | | X | |

ABSTRACT

An analysis and needs assessment was conducted to identify kindergarten through grade 14 (K–14) customer needs with regard to using the World Wide Web (WWW) for instruction and to identify obstacles K–14 teachers face in utilizing NASA Learning Technologies products in the classroom. The needs assessment was conducted as part of the Dryden Learning Technologies Project which is a collaboration between Dryden Flight Research Center (DFRC), Edwards, California and The Pennsylvania State University (PSU), University Park, Pennsylvania. The overall project is a multiyear effort to conduct research in the development of teacher training and tools for Web-based science, mathematics and technology instruction and learning. The project team conducting the research consisted of graduate students at PSU under the supervision of Dr. Barbara Grabowski, Associate Professor, PSU, and Dr. Marianne McCarthy, Learning Technologies Project Manager at DFRC. Jeff Ehmen of the Marshall Space Flight Center Spacelink program, Dr. Marchelle Canright of the Langley Research Center Office of Education and Lee Duke, Chief of Public Affairs, Commercialization, and Education at DFRC also contributed to the research effort. The areas investigated included administrative infrastructure, technology infrastructure, teacher factors, school curriculum, existing Web-based NASA materials, best practices using the WWW in the classroom, teacher tutorials and teaching and learning philosophy.

NOMENCLATURE

| | |
|----------|--|
| ARPA | Advanced Research Projects Agency |
| DFRC | Dryden Flight Research Center, Edwards, California |
| FRSS | Fast Response Survey System, U.S. Department of Education database accessible through National Center for Education Statistics |
| ISDN | Integrated Services Digital Network |
| K–12 | kindergarten through 12th grade |
| LCN | low cost networking |
| NCES | National Center for Educational Statistics |
| PPP | point to point protocol |
| PSU | Pennsylvania State University, University Park, Pennsylvania |
| SAIC | Science Applications International Corporation, Los Angeles, California |
| SLIP | serial line internet protocol |
| T1 lines | formatted digital signal at 1.544 megabits per second |
| T3 lines | formatted digital signal at 44.736 megabits per second |
| USC | University of Southern California, Los Angeles, California |
| WWW | World Wide Web |
| 56Kb | data transfer rate, about twice as fast as normal telephone transfer rate of 28.8 |

NEEDS ASSESSMENT

Introduction

The Pennsylvania State University and NASA Dryden Flight Research Center are working together to analyze, develop, implement, and evaluate instructional materials that enable teachers to use the World Wide Web effectively for teaching science, math, and technology. As part of the NASA Dryden Learning Technologies Project, the first phase in accomplishing this goal was to complete a needs assessment to determine how the web could be integrated into the classroom. This needs assessment examined the existing school infrastructure, science, math, and technology content in the curriculum and on the WWW, and the processes of teaching and learning to create the vision of how the current state of the classroom could be adapted to include the WWW as a classroom resource.

The needs assessment was conducted in three phases. In the first phase, the school context was analyzed. The second phase consisted of a review of the science, math, and technology content. Phase three consisted of reviewing the processes of teaching and learning, which in combination with the results of the first two phases resulted in the development of strategies that exemplify the most meaningful ways the WWW can be used in the classroom.

The investigation about school context focused on areas that are critical to integrating and using computer technology to deliver instruction in an educational setting. These included:

- administrative infrastructure,
- technology infrastructure, and
- teacher factors.

In the second phase of the assessment, school-appropriate science, math, and technology content areas were explored. The structure of the National Education Standards and school curriculum were studied along with how existing NASA Web-based material might fit within this structure. The areas of study included:

- school curriculum and
- existing NASA materials.

Within the third phase of the needs assessment, the teaching and learning processes were investigated. The investigators reviewed the ways that instruction could be presented most effectively for the teacher and the student. They included:

- best practices using the WWW in the classroom,
- teacher tutorials, and
- learning theories and teaching practices.

The purpose of the in-depth investigation of these eight areas was to identify which dimensions defined the area and further specify the critical factors for each of the dimensions. These dimensions and critical factors provided a structure for reporting the results found for each area.

Organization

The results of the needs assessment are reported in eight sections representing each area of investigation:

- Administrative Infrastructure
- Technical Infrastructure

- Teacher Factors
- Curriculum
- Existing NASA Materials
- Current Best Practices Using the WWW in the Classroom
- Teacher Tutorials about the WWW
- Learning Theories and Teaching Practices

Each section includes an overall definition of the area, the investigation procedures, key dimensions, and conditions. Each dimension was subdivided further by specific defining factors that made up that dimension. Each factor was in turn defined and supported with references, which are included in Appendices A and B. The references supported the findings. Exemplary schools or Web sites are also provided.

The conclusions summarize key trends that impact how, and more importantly if, the WWW would be used to support classroom instruction. Understanding each of these eight areas and their relationship to optimal WWW use in the classroom will ultimately aid in the development of teacher strategies and training.

ADMINISTRATIVE INFRASTRUCTURE

Administrative infrastructure refers to the policies and personnel that facilitate the use of computer technology in the classroom. Policies are those mandated at the Federal, State, District, or Local levels. Personnel include principals, vice principals, school board members, teachers, secretaries, parents, and outside sponsors.

Investigation

The administrative infrastructure issue was investigated by searching the Internet and the library for electronic and printed resources and documents, attending conferences, and interviewing administrators and technical support people. Information was reviewed from all 50 states, and data from 30 states were used. This information included both rural (20%) and urban/suburban (80%) school districts. Strategic plans to implement technology at the Federal, State, and Local levels were also reviewed. An assessment was made to determine how local administrators implemented Federal and State mandates. A major focus was on how individual school district administrators supported policies, funding, and teachers to incorporate computer technology and the WWW into the classroom.

One assumption made during this investigation was that the findings do represent current administrative infrastructures and that they can be generalized to school districts across the country. The most significant limitation of this study was the lack of direct feedback from administrators. Most of our research included extensive searches on the WWW and limited discussions with administrators and teachers met during conferences. Future interviews should include a group of representative administrators dealing with the issues of technology and the WWW in their school districts. Future investigations should also include interviews with parents and home-school administrators.

Dimensions

While many aspects of the administrative infrastructure impact the effectiveness of a school system to educate students, three important dimensions that are specific to the successful use of computer technology and the WWW in the classroom emerged: supportive administrators, supportive technology and services, and support for teachers.

Supportive Administrators

The level of support provided by the administrator in an overall management capacity and in day-to-day activities with teachers and support staff can set the pace for the use of computer technology in the classroom. The schools that were most successful at using computer technology and the WWW in the classroom had administrators who:

- were highly involved in establishing technology objectives and technology budgets,
- actively sought partnerships with outside sources to provide financial and technical resources,
- provided secretarial and administrative support personnel to support teachers in writing grants,
- provided an encouraging environment for change and experimentation, and
- integrated computer technology into administrative functions.

Supportive Computer Technology and Services

A key function of the administrative infrastructure is to provide the computer technology necessary for the teacher and to plan for providing access to that technology. Technical support, including equipment maintenance, system administration, and user support, was critical in maintaining ongoing, effective use of the computer. Measures which demonstrated positive and supportive computer technology services included:

- administrator understanding of State-level technology strategic plans,
- the existence of a local or district implementation plan,
- the existence of a technology plan for acquiring, maintaining and using equipment, and
- the existence of ongoing technical support.

Support for Teachers

The teacher makes the ultimate decision to use computer technology in the classroom and must know how to operate and integrate computers into their lesson plans, however, administrators must support the use of computer technology for it to become widespread. Effective ways administrators can support teachers include:

- providing release time,
- finding and providing qualified substitute teachers,
- developing teacher training plans,
- providing the expectation that computer technology will be integrated into the curriculum, and
- developing standards for computer competencies.

Each dimension is further defined in Appendix A 1. Supporting references are listed by dimension and factor in Appendix B 1.

Conclusions

Trends

Administrative, technical, and teacher support are all interdependent. If administrators are not highly supportive, computer technology may not be purchased, nor will teachers be released to use the computers. On the other hand, teachers can influence administrator involvement to further their efforts to incorporate computers into the classroom.

Outside partners, both public and private, have become more involved with administrators in planning, providing financial support, hardware, and support personnel. Administrators that advocated and planned for the use of computer technology and the WWW have been most effective in building and maintaining these partnerships.

Although 14 factors defined the dimensions of the administrative infrastructure, the following were the most critical for providing support to teachers to implement the use of computer technology and the WWW in their classrooms:

- supportive administrator: allocating funds to purchase equipment,
- supportive technology and services: hiring resources to provide training and technical support,
- support for teachers: providing release time and temporary substitutes for teachers involved in learning how to use the computer in their classrooms or helping other teachers use technology in their classrooms.

Most Critical Dimensions

Of the three dimensions identified, the following two represent the most critical for impacting the use of computer technology in the classroom for the subsequent reasons:

- **Supportive Administrators.** The budgeting, planning, and leadership skills of the administrators are crucial to the success of integrating technology in schools.
- **Supportive Technology and Services.** Without ongoing maintenance and technical support, computers can become unpredictable and unreliable for consistent and successful classroom lesson use.

Relationship to Other Areas Studied

- **Technology Infrastructure.** The number of instructional rooms with access, points of connectivity, speed of access, technical support, and plans for the future are all closely related to the administrative support dimension. Administrative support includes a commitment to a financial plan for configuration and support of teachers in the school.
- **Teacher Factors.** Skill level, attitude and motivation, and perception of administrative support are all highly related to administrative infrastructure. Administrators support teachers by motivating them and providing training on how to implement the use of computer technology and the WWW in their classrooms.
- **Curriculum.** Administrative support and teacher support relates closely to how technology is used in the curriculum; for example, how the National Education Standards are incorporated with the use of computer technology. Administrative support also relates to how computer technology may be used to support reform efforts. As Federal, State, or Local reform efforts call for the use of computer technology, the Administrative Infrastructure needs to be adjusted to accommodate change. Administrators, therefore, need to have a clear concept of how the curriculum is supported with computer technology.
- **Best Practices Using the WWW in the Classroom.** Best practices using computer technology in the classroom may require upgrades to equipment, and are therefore related to supportive technology and services as well as administrative support.

TECHNOLOGY INFRASTRUCTURE

Technology Infrastructure refers to the physical characteristics of the WWW connection to a school. This connection can take many different forms and configurations and serve a variety of purposes, including classroom instruction. The WWW infrastructure is not static, in that many of its dimensions are scaleable and modifiable over time. As one dimension changes, the other dimensions of technology infrastructure may also change.

Investigation

The dimensions of the technology infrastructure stem from categories of data collected from the National Center for Educational Statistics (NCES). All of the data within each dimension were then collected from two main sources: The Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996 report from NCES and an e-mail interview with Rebecca Beaty, Program Manager, Science Applications International Corporation (SAIC). This Los Angeles-based company specializes in coordinating information technology solutions for commercial as well as educational ventures.

The most important assumption behind the investigation of this report is that NCES, a nationally recognized research agency, provided the most reliable and accurate accounting of the technology in the schools. Many other sources were consulted and dismissed as providing too narrow a focus, or being biased or incomplete.

Low cost networking (LCN) strategies, while recognized as important, were considered too late for inclusion in this analysis. Having options for networking strategies that are low cost to schools does impact an administrator's decision about implementing technology. More information is available from NASA Lewis and Langley Research Centers. Administrator and technology support staff awareness of these low cost options should also be considered in future studies.

Dimensions

The dimensions of the technology infrastructure have a major effect on the type of instructional activities that can be performed. The level to which each dimension is implemented establishes a boundary within which instruction can take place. All dimensions are dependent upon each other and restrict or enable each other, resulting in a pre-specified window of opportunity for using the WWW in the classroom. Any technology plan should include a consideration of these factors. The critical dimensions of the Technical Infrastructure include:

Points of Connectivity

A point of connectivity refers to the physical location where the WWW connection is used within a school. The two points of connectivity that affect instructional use are in:

- instructional rooms, and
- non-instructional rooms.

Number of Instructional Rooms Having Access to the Internet

The number of rooms that have access to the Internet will affect how widespread its use will be in a school. This dimension is broken down into a sliding scale from no rooms (none) to five or more.

Type of Network Connection

Because the different type of media available on the WWW are expanding rapidly, the level of connectivity becomes an issue since it refers to the volume of data transfer over the connection from slow to fast. (See Appendix A 2.) The types of connectivity currently available are:

- modem,
- SLIP/PPP,
- 56Kb,
- ISDN,

- T1 lines, and
- T3 lines.

Existing Plan for Connection by the Year 2000

One encouraging aspect of connectivity is the expanding number of states with plans for connecting to the WWW by the year 2000. Given this factor, the potential of schools is assessed against whether or not they have included connectivity in their plans:

- included or
- not included.

Technical Support

The level of technical support a school has is a key factor in determining how easily a school obtains and maintains connectivity. This dimension is defined by two levels:

- low to none, which indicates low availability of technical support, supplying only reactive services when a problem arises, and
- high, which indicates high availability of technical support and active system maintenance.

Each dimension is further defined in Appendix A 2. Supporting references are listed by dimension and factor in Appendix B 2.

Conclusions

Trends

Key trends as reported by the National Center for Educational Statistics, Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996: (Note: These trends are quoted verbatim from the NCES document, Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996, <http://www.ed.gov/NCES/pubs/97944.html>)

- Overall, 65 percent of public schools had Internet access while 35 percent had no Internet access during fall 1996. While 65 percent of schools were on the Internet, only 14 percent of all instructional rooms in U.S. public schools had Internet access.
- Of the schools with Internet access, 95 percent indicated that they had Internet access in at least one instructional room, such as a classroom, computer or other lab, or library media center. Of these 95 percent, 43 percent reported access in one instructional room, 22 percent had Internet access in two or three instructional rooms, 4 percent reported access in four instructional rooms, and 25 percent had Internet access in five or more rooms.
- Schools connect to the Internet in a variety of ways, although modems remained the most common means of connection. In fall 1996, 74 percent of schools with Internet were connected by modem. Higher speed SLIP or PPP connections were used in 20 percent of these, 12 percent had a T1 connection, 11 percent had a 56Kb connection, and 4 percent connected to the Internet with an ISDN line.

NOTE: The percentage of public schools with each type of connection is based upon schools with Internet access, 65 percent of public schools had Internet access in 1996. Percentages do not sum to 100 because some schools had more than one type of Internet connection.

- Of the remaining schools that do not currently have Internet access (35 percent of all schools), 87 percent have plans to obtain access to the Internet in the future while 13 percent have no plans to have access to the Internet. Hence, all but 5 percent of public schools had plans to connect to the Internet by the year 2000.
- Though a majority of schools have Internet access, little of it is used for instruction. When the Internet is used for instruction within a school, the majority of schools only provide access in one instructional room and that connection is most likely over a modem. By the year 2000, 95 percent of schools plan to have access, but it is not clear to what degree this access will be for instructional purposes.
- The issue of technical support appears to be poorly addressed, as if the technical responsibility belongs to the teachers using the Internet.

Most Critical Dimensions

Based on the analysis, the most critical are:

- points of connectivity,
- number of instructional rooms having access to the WWW,
- technical support,
- types of network connections, and
- existing plan for connection by the year 2000.

The consensus of the needs assessment team was that of all the Technical Infrastructure dimensions examined, the most important were “points of connectivity” and “number of instructional rooms having access to the WWW.” To increase WWW use in the classroom, points of connectivity must increase from the current 14 percent and the number of instructional rooms with WWW connections needs to increase from the current 43 percent with only one room connected.

Relationship to Other Areas Studied

- Technology Infrastructure relates to Administrative Infrastructure in an important way. Administrators can benchmark their existing technological infrastructure against their vision of classroom use of computer technology and the WWW. With this benchmark, they can then determine in what ways their technology plan needs to change to make their vision a reality. The administration also has to provide for ongoing technical support.
- Limited access of the technology infrastructure imposes restrictions on the ability of a teacher to integrate Web resources into his or her instructional activities.

TEACHER FACTORS

Teacher factors that impact the use of the WWW in classroom instruction included internal, personal characteristics and external characteristics related to what the teacher does. By examining internal, personal characteristics such as attitude, skill, and knowledge one can determine how (and if) the WWW will be used, or the probability of its being used if access is obtained. External factors include classroom and teacher assignments.

Investigation

Many different methods of investigation were used in this needs assessment. The first strategy was to review print and Web-based resources to uncover some general characteristics about teachers. The U.S. Department of Education Web site was a good starting point, providing many links to studies and surveys by reputable organizations

such as the National Center for Education Statistics. In addition to examining the extant data, some informal surveys were conducted. A pool of approximately 50 questions was generated and each survey given was created from that collection. Two paper-based surveys were distributed and tallied; two “focus” group sessions were held and the results were tabulated and recorded by members of the project team. The following other web-based telecommunications techniques were used in the analysis: e-mail was regularly exchanged between members of the project team and other teachers; educational listservs provided profiles of the teacher audience; and teacher chat rooms were good places to exchange ideas and generate discussion. Data were collected from Pennsylvania, Virginia, and Maryland through the focus groups. It is unknown how many states were represented through the electronic interactions of e-mail, listservs, and chat rooms.

Two assumptions made in this investigation were that a majority of classroom teachers do not have access to the WWW or other technologies and that most teachers lack the skills necessary to integrate the WWW effectively into their lessons. Those teachers who have access to the WWW include both “power users” who take advantage of the capabilities of the WWW and those teachers who do not know how to use the technology and have not integrated it into their lesson plans. Another assumption was that technology will become more prevalent in schools and teachers do want to know more about technology use in the classroom, but they do not have the time or staff support to do so.

The most significant limitation was the small sample size of the teachers who were interviewed directly. Also, the informal surveys and interviews targeted teachers who had access to the WWW and were interested in using technology in their classrooms. However, the NCES surveys provided a valid and representative source of data that captured national statistics on a wide variety of teachers under several different circumstances, such as limited WWW access, rural schools, and disadvantaged districts.

Dimensions

Seven dimensions were found that categorized the important areas related to how teachers use the WWW in the classroom. These included:

Technical Skill

Technical skill refers to the ability of the teacher to use and integrate technology in the classroom. Three categories were used to define this skill level: low, medium, and high.

Attitude and Motivation

Attitude and motivation refer to the mental states that impel teachers to learn new computer-related skills and motivate them to incorporate the computer and WWW into classroom instruction. Two levels were used to define the teachers’ level of attitude and motivation: positive or negative.

Perception of Skills

Perception of skills refers to the comfort or confidence of the teacher to incorporate computer technology successfully into the classroom regardless of whether they have the technical skill. Teacher perception of skill was classified as low, medium, or high.

Perception of Administrative Support

Perception of administrative support refers to how the teacher perceives the administration in terms of how encouraging they are about the use of computer technology and the WWW in the classroom. Three levels of perceived support were also used: low, medium, or high.

Assignment

Assignment refers to the grade level a teacher is assigned, either elementary or secondary.

Subject Area

Subject area refers to whether a teacher teaches general education or has a specialized content teaching assignment.

Time Teaching Science and Math

Time teaching science and math refers to the percentage of the day the instructor teaches these two subjects, and is categorized into low (up to 20 percent), medium (21 to 40 percent of the day), and high (above 41 percent).

Each dimension is further defined in Appendix A 3. Supporting references are listed by dimension and factor in Appendix B 3.

Conclusions

Trends

- Technical skill to integrate computers into classroom instruction will depend to some extent on technical support in getting the computer and network “up and running.”
- The teacher’s technical skill to integrate computers into the classroom is critical for implementing Web-based instruction. While minimal computer skill is necessary for basic collaboration on the WWW and finding and using information on the WWW, some technical ability is needed for more advanced tasks such as transferring files, downloading, and accessing other computers remotely.
- Attitude and motivation are critical for implementing Web-based instruction in the classroom. If teachers feel the information available on the WWW is useful for their class, it is more likely they will implement it.
- Attitude and motivation depend somewhat on administrative support. If teachers perceive that administrators do not value the WWW as an instructional tool, only a high determination and intent will overcome this negative influence.
- Assignment, subject area, and time spent teaching math and science are all factors that affect the amount of scientific, mathematical, or technological material that can be used from the WWW.
- Although perception of administrative support is not necessary for successful implementation of Web-based instruction or teacher materials, it affects teachers’ motivation to use computer technology in their instruction.
- Perception of skill will affect a teacher’s motivation to implement Web-based instruction. Perception of skill will also be affected by technical support in the school. If teachers have confidence that someone will solve their technical problems, they will feel more confident in their ability to successfully carry out a Web-based lesson.
- NASA can impact more teachers by targeting elementary, non-specialist teachers because they represent the largest group of teachers in the U.S., however, they teach the fewest hours of science.
- NASA can impact more classroom hours by targeting secondary specialists in math and science where there are fewer teachers, but more classroom hours are devoted to math, science, and technology.

Most Critical Dimensions

Our findings suggest that the two most critical teacher-related dimensions in determining the extent to which Web-based materials will be effectively used in the classroom are:

- Technical skills, that is, the teacher's current skill or ability to integrate technology in the classroom. A teacher's ability to integrate technology-based material in the classroom takes more than just computer "know-how." Teachers need to know how to best use the WWW to produce efficient, motivational, effective instruction. They need to know when a computer is more advantageous and efficient than traditional media.
- Teachers' attitude and motivation to integrate technology in the classroom. A positive attitude and high motivation are also critical for implementing Web-based instruction in the classroom. Even if a teacher had the necessary skills to implement computer-supported or Web-supported instruction, the teacher would still need to possess the motivation to make the effort. A positive attitude may encourage a less technologically capable teacher to acquire the skills needed to implement Web-based activities in the classroom.

Relationship to Other Areas Studied

- Administrative support has a strong impact on teachers in several ways. Administrators can provide funding and personnel for training and technical support. Administrators can create a positive atmosphere in which teachers can develop a positive attitude and high level of motivation to include technology in their classroom curriculum, thereby affecting teacher perception of administrator support.
- Technology infrastructure impacts teachers as well. Teachers can only use technology if it is available to them. To use Web-based material, teachers need access to computers that are connected to the WWW.

CURRICULUM

Curriculum refers to the overall plan for the delivery of instruction. Curriculum planning consists of two components: the content and the process for its delivery. Curriculum developers must be concerned with the message and the media of instruction. The WWW provides teachers with new ways to deliver instruction as well as new resources for content.

Investigation

Science and math curricula were examined to determine what exists now and what trends there are for future curricula development. The investigation centered on how the WWW and computer technology could support math and science curricula. The WWW was searched for government documents, National Education Standards, and curriculum resource sites. Library resources were reviewed for current research and other publications related to school curriculum issues.

Dimensions

This study identified three broad dimensions of the WWW as a resource for curriculum:

Curriculum Guidance

The WWW is a ready reference for National, State, and Local Education Standards, outcomes, and/or frameworks. Four categories were identified for this dimension:

- National Math and Science Education Standards,
- math standards which emphasize problem solving, communication, reasoning, and relationships,
- new science curriculum which emphasizes concepts, theories, ideas, inquiry, and interrelationships, and
- State Education Standards/Frameworks that provide local interpretation of the National Education Standards.

Curriculum Support

The WWW can support a variety of instructional classroom strategies. Four categories of curriculum support were identified:

- traditional classroom model of group instruction in the classroom,
- individualized instruction,
- interdisciplinary curriculum, and
- learner-centered models to teaching and learning.

Curriculum Resources

The WWW offers many types of curriculum resources that support classroom teaching. Two categories were identified to classify this dimension:

- finding and evaluating resources which include search engines and evaluation tools, and
- type of resources, further classified as lessons, activities, projects, resources, references, tools, and private for-profit subscription services.

Each dimension is further defined in Appendix A 4. Supporting references are listed by dimension and factor in Appendix B 4.

Conclusions

Trends

Recently, more science and math curricula are based on the National and State education standards, outcomes and frameworks. With the national vision to achieve a higher level of scientific literacy and technological competence, national education standards were developed. National and State standards are a new reality facing today's teachers. Standards provide consistency and validity to instruction. Moreover, standards furnish reliable benchmarks for assessment and evaluation as well as providing a common language for communication across groups, schools, states, etc. The WWW is a resource for information about standards, for finding educational materials that meet these standards, and for communicating with others concerned with standards.

Some educators state that the first step to using the WWW in the classroom is to find ways to integrate it into existing curriculum. The WWW can support an individual course as well as interdisciplinary curriculum models. Others believe that WWW technology can be a tool for helping school instruction change into a more learner-centered model as well as to support other reform initiatives.

The WWW is a significant resource of curriculum materials (lessons, activities, projects, references, tools, etc.). Teacher-oriented databases with easy-to-use search engines are needed to help teachers find appropriate materials for their classroom. New private companies offer subscription service and curriculum help by organizing and evaluating WWW resources for the teacher.

Most Critical Dimensions

All dimensions assessed in the report are critical to the success of the integration of the WWW into the classroom. The importance of the dimensions may shift as the WWW grows in popularity in the classroom and other learning environments.

- **Curriculum Guidance.** Curriculum developers must be aware of the National Standards for Math and Science Education as more and more states come into compliance with those standards.
- **Curriculum Resources.** The WWW provides a wealth of resources for curriculum developers in content and tools. The WWW can function as an electronic library for lesson plans, activities, projects, and references.
- **Curriculum Support.** Curriculum support will increase in importance as more instruction is delivered through the WWW. The shift to student-centered learning will increase the WWW's role in the support of curriculum.

Relationship to Other Areas Studied

- **Administrative Infrastructure.** The administrative infrastructure and curriculum specialists support curriculum content and delivery. Administration can focus the curriculum content on the National Education Standards and foster the inclusion of the WWW as a medium of delivery.
- **Technology Infrastructure.** Curriculum delivery and to a lesser extent curriculum content are dependent on the technology available within the school. Access to Web-based curriculum resources can only be assured when there is support for hardware, telecommunications services, and maintenance.
- **Teacher.** Teacher willingness to change and to learn is a key factor for the successful integration of WWW technology into the curriculum. Teachers must be trained in the techniques of accessing information through the WWW before computer technology can be used to support (and perhaps change) the way curriculum is delivered in the learning environment. Computer literacy and proficiency with Web-based communications must precede any attempts at integration.
- **Existing NASA Materials.** The accessibility of NASA materials and their adaptability to K–12 curricula will determine the extent to which they will be used in the classroom.
- **Best Practices Using the WWW in the Classroom.** The WWW can provide teachers and curriculum developers with a wealth of examples of how WWW technology can be used in the classroom. The best place to learn the fundamentals about the WWW is on the WWW.

EXISTING NASA MATERIALS

The purpose of this investigation was to search for Web-based NASA educational materials, focusing first on NASA Dryden Flight Research Center materials and then on Web-based educational material from throughout NASA. These materials were examined for their benefit to K–12 public and private school teachers and their students.

Investigation

The investigation began with a search for educational materials that the DFRC had available. The materials were examined to determine the type of material available and how it was organized. The categories were clarified with NASA educational representatives. Next, dimensions were formulated that were representative of the information that was available. Finally, these dimensions were validated with other needs assessment team members and NASA representatives.

Due to time constraints, all of the NASA education resources available were not reviewed; however, the investigation did cover a sampling of what NASA currently has to offer. A list of the NASA sites visited is reported in Appendix B 5. The resulting dimensions representing the WWW materials that NASA DFRC has available are assumed to be representative of most NASA material.

Dimensions

Eight dimensions sum up the current material available. Each dimension was defined as follows:

Databases

Databases include sources of current data that students can manipulate and examine to learn about scientific concepts:

- glossaries,
- catalogs for teachers to order NASA materials (including video tapes, slides, pictures, print materials, posters, software), and
- archived material (including text and pictures that can be downloaded).

Information and Resources

Information and resources refers to text, pictures, and staff available to help teachers gain information. The following types of information and resources were found:

- fact sheets,
- news releases,
- biographies,
- photographs,
- workbooks,
- staff, and
- handbooks.

Lesson Plans

Lesson plans are precreated plans of learning which can be used in classrooms. These were grouped into the following grade levels:

- K–4,
- 5–8, and
- 9–12.

Projects

A project refers to ventures between teachers and students and NASA staff or data.

Student Activities

Student activities refer to interactive games and manipulatives provided for student use and were grouped by grade levels:

- K–4,
- 5–8, and
- 9–12.

Tools

A tool refers to a software program that can expand one's WWW "surfing" skills and includes search engines and downloading tools.

References and Links

References and links refer to NASA and non-NASA Web sites that are hyperlinked to NASA sites.

A Tutorial

A tutorial refers to a Web-based lesson for teachers or students.

Each dimension is further defined in Appendix A 5. Supporting references are listed by dimension and factor in Appendix B 5.

Conclusions

Trends

- Most Web sites can be classified as information or resources.
- Many of the instructional materials effectively transfer NASA subject matter for use in classrooms; for example, those sites that have self-contained lesson plans for building spaceships.
- Most WWW lesson plans use materials that are available to teachers and include interesting and helpful content.
- The instructional material should be developed for use by elementary school students as well. Some materials were developed at too high a level for broad K-12 use.
- NASA Dryden needs to promote its content to teachers so they know what materials exist.
- Screen formatting which uses frames may cause teachers difficulty in navigating through the DFRC materials.
- The newer NASA lesson plan formatting that includes grade-appropriate levels allows teachers to access what they need more quickly.
- Downloading may cause problems in several areas:
 - additional software may be needed to support the material;
 - it may be too time consuming to get what is needed because of large files or slow access rates; or
 - more hard drive space might be needed for storing material.
- NASA Dryden is young in its development of materials for teachers on the World Wide Web.

Most Critical Dimensions

- **Lesson Plans.** Lesson plans are included as one of the most critical dimensions because they are written in a style that is easily infused into the curriculum and therefore reach the students quickly.
- **Student Activities.** Student activities are critical because they are also easily infused into the classroom.
- **Databases.** Databases are included as one of the most critical dimensions since they allow teachers to search large bodies of information to find what they need for their own curriculum.

Relationship to Other Area Dimensions

- **Administrative Infrastructure.** Teachers will need to have the correct equipment, training, and technical support to implement the existing NASA materials into their classrooms.
- **Technology Infrastructure.** The current WWW connections to schools may not allow the teacher to reach or download existing NASA materials in a timely manner.
- **Teacher Factors.** The existing NASA materials should not exceed the technical ability and subject area of the teacher audience to be best utilized in the classroom.
- **Curriculum.** The more highly related the NASA materials are to the local, state, and national curriculum guidelines the more likely they are to be incorporated into classrooms.
- **Best Practices Using the WWW in the Classroom.** Collaborative activities provided by NASA motivate teachers to integrate the materials into their classrooms.
- **Teacher Tutorials.** The more proficient teachers become at using Web-based instructional resources, the more likely that they will integrate NASA educational materials into their classrooms. Tutorials are one way to provide the teachers with the technical training they need to download, understand, and use NASA educational materials.

BEST PRACTICES USING THE WWW IN THE CLASSROOM

There are many techniques and activities that can be used in the classroom to enhance learning. Incorporating Web-based lessons and activities is one way teachers can utilize computer technology to enhance learning. Web-based lessons that are designed well, effectively integrated into lesson plans, and are well executed can enhance the learning process. Effective learning environments engage students in intentional, active, constructive, contextualized activities (Jonassen, 1997). In reported best practices, teachers are using the WWW to facilitate learning through collaborative activities with individuals inside and outside the classroom. These teachers are challenging students to use the WWW to research content areas that support lesson goals. Students also are using the WWW to create new or manipulate existing data to support lesson objectives.

The goal of this assessment was to identify the best practices of teachers using the World Wide Web in their classrooms for instructional purposes. This included looking at how the WWW was being used as well as examples of lesson activities and sites being accessed. The findings suggest that there are several ways that teachers are using the World Wide Web to enhance the learning environment and a variety of types of instructional activities.

Investigation

Best practices in using the World Wide Web were investigated by searching for exemplary sites, reviewing current printed material designed to help teachers integrate Web-based activities in their classroom, attending conferences, and interviewing teachers in K–12 and university level programs that use the WWW to deliver instruction. The focus of the research was to identify how the World Wide Web was being used by the teachers, how students interacted with sites, and the types of sites being used for different types of activities.

Dimensions

The critical dimensions of Best Practices Using the WWW in the Classroom included:

Use of the WWW During Instruction

This dimension focuses on how teachers used the WWW in their lessons. For example, the WWW may be used as the sole delivery mechanism for the lesson or it may be used as a collaboration tool to share experiment results

with many students completing experiments offline. The difference between these two approaches is how the Web is used either as the primary mechanism to provide instruction, content, and feedback or as a tool to communicate and collaborate during adjunct activities. Four categories were found that exemplified this dimension:

- distance learning,
- WWW as sole delivery mechanism in classroom,
- WWW with other offline activities, and
- WWW as a demonstration tool.

Interactivity with the World Wide Web

This dimension focuses on how the World Wide Web was used by the students. For example, students use the WWW as a research tool to find information, data, or graphics; as a tool to communicate with others; or as a tool to manipulate and report data. Five categories were found that exemplified this dimension:

- access to people,
- access to information,
- access to both people and information,
- creation and generation of data, and
- manipulation and sharing of existing data.

Types of World Wide Web Sites

Types of WWW sites refer to the potential function of the site in the classroom. Sites can be classified into three categories:

- informational,
- instructional, or
- learning (Grabowski and Curtis, 1991).

Informational sites primarily present data, explanations, examples, images, and content. Instructional sites organize and sequence information into lesson plans or activity instructions. Learning sites engage the learner in cognitive processing and interactive investigation of content with the intent of encouraging learning.

Origination of Sites

The origination of sites refers to who created the Web site. This is important to teachers and students when there is a concern about content accuracy and quality of the Web site. Web sites can be created by

- teachers,
- students,
- content authorities, or
- the general public.

Each dimension is further defined in Appendix A 6. Supporting references are listed by dimension and factor in Appendix B 6.

Conclusions

Trends

- Using the WWW in the classroom is still a fairly rare occurrence, given that the technology infrastructure is lacking in most schools. Those that do report success have taken an experimental approach, trying different types of lessons, incorporating richer activities over time. Richer activities include taking advantage of the unique attributes of the WWW which enable communication and the ability to share information and results across wide distances.
- The WWW can be used successfully as a distance education tool when users have access and are comfortable with technology, instructions are clear, and the instructor maintains a high level of online or offline interaction with the student.
- Teachers who have used the WWW in their classrooms have taken experimental approaches that generally begin with “low” interactivity and move into “high” interactivity.
- Lessons that incorporate the WWW only as an information resource, with no clear goal in mind, do not generally stimulate the students. However, when there is a clear instructional goal or intent, generated either by the teacher or the student, WWW searching becomes purposeful and valuable.
- Most of the successful uses of the WWW in the classroom incorporate Web- and non-Web-based activities. These activities encourage students to use the communication aspects of the WWW, provide students with specific problems to investigate, encourage data manipulation and sharing, and require collaboration either online or offline.
- Although the technology in many classrooms is slow, teachers have downloaded or cached text, images, and videotape clips prior to class to save loading time. Some teachers have also started to use Web-site capturing software to load sites of interest onto non-internet connected computers. In these ways, teachers have been able to take advantage of Web resources previously unavailable to them because of time considerations.

Most Critical Dimensions

- use of technology during instruction
- interactivity with the World Wide Web

The most critical dimensions in this investigation are “how technology is being used” and “how students are interacting with the WWW”. Where there were unsuccessful first attempts at using the WWW, teachers changed how technology was used or the type of interaction students had with the WWW. For example, in one case the teacher set up a computer lab for a social studies and geography lesson. Students, he thought, would be intrinsically interested in going to each of the computers, which had bookmarks for different countries, and just explore the world. Students did not come. There was no reason for them to explore on the computer when they could just open their geography book. The teacher changed the activity by connecting his students with students from around the world and by setting a context in which the students were to write a short essay on the “day in the life of someone from....” The students began to collaborate with their e-mail pals and learn about the different countries. He noticed that they explored the location of neighboring countries, looked up historical facts, and started to develop a knowledge of the different geographic regions.

Relationship to Other Areas Studied

- **Technology Infrastructure.** Access to technology and speed of connectivity are critical to using the WWW for instruction. Without access, the possibility of using the WWW is zero. Speed of connectivity is critical because of the limited amount of time available in the school day that can be devoted to downloading large documents or waiting for WWW connections to be made. With pre-caching capabilities, however, this becomes less of an issue.

- **Teacher Factors.** Skill level is important in operating the computer and integrating online activities into the classroom. Teachers also need to have a positive attitude and be motivated to use the WWW. Teachers with high motivation will find creative ways to use the WWW during lessons and be more apt to try different approaches if one fails.
- **Teacher Tutorials.** Teaching teachers how to use the WWW in a variety of ways is critical to their success in supporting Web-based instruction. Tutorials provide a way for teachers to learn different ways to take advantage of the WWW by learning how to create their own sites or by seeing new ways to integrate the WWW into their lessons.

TEACHER TUTORIALS

Teacher Tutorials help teachers make use of WWW resources in a classroom setting. The tutorials in this needs assessment focused on skills related to both instructional and technical issues. To use the WWW in the classroom, teachers need varying degrees of technical proficiency combined with strategies and skills relating to designing instruction and writing lesson plans.

Investigation

The process used to investigate WWW tutorials that are appropriate and available to K–12 teachers was diverse and varied. It was based on a collective knowledge of the target audience and the field of study. Through extensive web searches, literature reviews, brainstorming, discussions, review of conference agendas, trade books, and magazines, we were able to gather volumes of data for synthesis into the findings. Tutorials that taught the technical fundamentals of using the WWW, and those that taught instructional fundamentals, or how to integrate the WWW into classroom instruction were identified and sorted according to the level of structure involved in their use. While the tutorials represented varying levels of quality, they were not evaluated to determine how successful they were at achieving their goals. Rather, characteristics of each tutorial were sought.

Dimensions

Teacher tutorials were broken down into two dimensions. The teacher's level of proficiency in either dimension affects their ability to use the WWW for instruction.

WWW Producer

The dimension of a producer refers to tutorials that teach teachers to create and publish content for WWW delivery. The WWW producer tutorials were subdivided into two categories:

- high producer tutorial, that is, one that teaches how to create content, manage WWW pages, write code, use multiple media types, create interactive sites that require less internal initiative, and
- low producer tutorial, that is, one that teaches how to produce single media pages, create passive, non-interactive pages that require more internal initiative.

WWW Integrator

The dimension of integrator deals with tutorials that teach teachers how to enhance their classroom instruction with the resources of the WWW. This dimension was also subdivided into two categories:

- high integrator tutorial, that is, one that teaches how to identify resources, use e-mail, facilitate communication, moderate discussion groups, design and foster interactions, use multiple media sources, foster an interactive environment, and

- low integrator tutorial, that is, one that teaches how to use a single or few WWW resources, or how to use the Web for demonstration rather than engage learners interactively.

Each dimension is further defined in Appendix A 7. Supporting references are listed by dimension and factor in Appendix B 7.

Conclusions

Trends

- Teachers must develop the knowledge and skills to integrate WWW resources into classroom instruction so that they become proficient in using Web-based instructional resources.
- Adequate teacher tutorials demonstrating methods of incorporating Web-based content into instruction exist; however, teachers have difficulty locating this information because it is embedded in a much larger volume of tutorials on how to design and produce Web pages.
- Many resources titled “Integration” actually only cover the topic of “production” of WWW content. The result is that teachers are flooded with redundant information on issues of production and must exert considerable effort to find relevant integration strategies. Also, these resources have relatively little structure and require a great deal of initiative from the teacher to master the skills and knowledge of WWW production.
- Resources for integration are also available outside the WWW. These resources are generally facilitated events, such as workshops, conferences, inservices, and seminars provided for teachers to learn integration skills. These facilitated events tend to have greater structure and are easily accessible, but typically involve a financial cost that limits their general accessibility.

Most Critical Dimensions

WWW Integrator. Successful use of the WWW should be determined by a teacher’s ability to incorporate, or *integrate* the WWW into the existing classroom curriculum and environment. Therefore, while some materials are directed toward the development of Web-based materials, it is more critical to teach teachers how to become integrators of the WWW rather than producers of Web-based material.

Relationship to Other Areas Studied

- **Best Practices Using the WWW in the Classroom.** When developing teacher tutorials, case studies should be drawn from what has already been learned about how technology is used during instruction. These best practices could become examples for the instruction. Likewise, those tutorials that teach teachers how to integrate the WWW should include the various perspectives of Web interactivity.
- **Learning Theories and Teaching Practices.** The tutorials that teach teachers how to use the WWW in their classrooms should take into account the latest research about how children learn. These strategies can be gleaned from contemporary learning theory.

LEARNING THEORIES AND TEACHING PRACTICES

In developing materials to help teachers better utilize NASA’s Web-based materials, several theories of learning were considered. In this section, the dimensions represent broad perspectives on the learning process. The levels represent different theories that fall under each perspective, and are followed by a description of each theory and how it may be applied in the classroom.

Theories of learning should be considered by designers when they are creating Web-based learning environments for several reasons. First, Web-based materials need to represent “good” instruction. Good instruction can be

fostered by creating a match between instructional methodology and the materials to be taught. Learning and instructional theories help us accomplish this goal. For example, presenting astronaut biographies in a way that teachers can use them for constructive learning environments may be better suited to a teacher's instructional goals than presenting them in a way that would allow teachers to use drill-and-practice worksheets. Second, many teachers use different approaches to learning in their classrooms. If materials on the WWW are versatile and meet the current needs of teachers, teachers may be more likely to use those materials. For example, if teachers know that they like to use cooperative learning environments in their classroom, they would probably appreciate the ability to search for lessons that use cooperative learning approaches.

Investigation

The methods used to compile this list included searching library resources, WWW, and other sources for information on theories of learning and instruction. Several experts in theory-related fields were also consulted. Next, the theories were grouped into categories and summaries were formed. Finally, teachers were asked about the kinds of instructional approaches they typically took in the classroom. These were then compiled into five dimensions.

Dimensions

Each dimension is described below:

Behavioral Perspectives

Behavioral perspectives refer to the learning processes in terms of changes in observable behaviors. Changes in behavior are attributed to the pairing of stimuli and responses with positive or negative reinforcement. Two theories which exemplify this dimension include:

- operant conditioning, and
- applied behavioral analysis.

Cognitive Perspectives

Cognitive perspectives refer to the structures and processes involved in thinking and how these structures and processes are learned and developed over time. Ten theories which illustrate this dimension include:

- constructivism,
- generative learning,
- self-regulated learning,
- metacognition,
- concept learning,
- dual coding theory,
- schema theory,
- problem solving,
- elaboration theory, and
- tetrahedral model of learning.

Motivational Perspectives

Motivational perspectives refer to factors that influence a learner's desire and ability to learn, such as level of task difficulty, attribution of success to oneself or others, and expectation for success. Four theories which exemplify this dimension include:

- flow theory,
- attribution theory,
- achievement goal theory, and
- expectancy theory.

Sociocognitive Perspectives

Sociocognitive perspectives refer to the effects of social characteristics such as age, socioeconomic status, and ethnicity on cognitive processes and learning. Two theories which exemplify this dimension include:

- social development, and
- cooperative learning.

Developmental Theories

Developmental theories refer to learning in terms of how changes during childhood affect the learning process. Two theories which exemplify this dimension include:

- stage theories, and
- non-stage theories.

Each dimension is further defined in Appendix A 8. Supporting references are listed by dimension and factor in Appendix B 8.

Conclusions

Trends

Given the current trends in education, the following conclusions can be made with regard to teachers' theoretical perspectives:

- Most teachers use an eclectic combination of behavioral, cognitive, motivational, and sociocognitive perspectives. Teachers try to match their approach with the task and the learners.

Most Critical Dimensions

No one perspective of learning theory will contribute more than the others to the successful implementation of the WWW in the classroom. Rather, there are several issues across all the dimensions that will affect the extent to which Web-based materials will successfully meet the needs of teachers to impart learning. In this regard, the type of Web-based strategy needs to be:

- varied,
- appropriate for the learners involved, and

- one which applies learning theory appropriately.

Applying one or more of the theoretical approaches to using the Web in the classroom should ultimately result in a more effective learning environment. The hands-on, minds-on approaches to learning increase student performance.

Relationship to Other Area Dimensions

Learning theory is only one of the factors that will affect the willingness of a teacher to incorporate Web-based instruction and teacher materials into the classroom. Another is the teacher himself or herself.

Teacher Factors

Teaching and learning theory comes into play only after a teacher has already decided to incorporate Web-based instruction or teacher materials into the classroom. At that point, it has the following impact:

- teachers specifically look for materials consistent with their traditional style of teaching,
- teachers look for materials that will expand their current styles to provide more instructional variety, and
- teaching and learning theory perspective may sometimes affect the extent to which a teacher values computer-based or Web-based lessons or material. In this sense, theoretical perspective may affect a teacher's motivation and attitude toward integrating World Wide Web instruction or material in the classroom.

Teacher Tutorials

Instruction on classroom use of the WWW that follows one of these theoretical perspectives can include Web creation, Web integration, or Web-enhancement to instruction.

NEEDS ASSESSMENT CONCLUSIONS

As stated by McCarthy in the Preface to this document, the WWW will make, and is making, a global economic impact on our lives—one that schools need to acknowledge so that they are able to prepare children for that world. The purpose of conducting this needs assessment, therefore, was to gain a better understanding of the school context, school content and WWW resources, and current learning theory and teaching practices so that appropriate teaching and learning strategies for using the WWW in the classroom could be developed. The overall findings from this analysis are reported in these three areas from the perspective of the customer, the teachers who ultimately have the responsibility of deciding what happens in their classrooms.

School Context

Three interrelated areas of school context exist: administration, technology, and teachers. For the WWW to be integrated into a school successfully, all of these areas must be addressed and resolved.

Teachers are motivated to learn about the WWW and how it can be used in their classroom. Teachers, however, are faced with major challenges in the following areas:

| School Context Realities | Recommendations |
|---|--|
| Access | |
| Although Internet access in schools is changing daily, teachers who do not have instructional access cannot even consider the WWW as an educational resource. | Prepare teachers for the eventuality that they will one day have Internet access. |
| Four different configurations of access in the classroom exist: classroom access, lab access, resource room access, and home access only. These access options also vary depending on the number and type of computers available. Each access option presents unique challenges for using the WWW in the classroom. | Help teachers determine how the WWW can be used within their own school and classroom configuration so that its use is seamless to their instruction, rather than being used solely as a "big-time event." |
| Speed of access challenges even the most creative and motivated teacher when they only have slow modems. | Help teachers understand that the WWW has many options and strategies for addressing slow modem speeds, and that the most glitzy sites may not be the most educationally effective. |
| Skill | |
| Teachers have a limited understanding of what resources exist on the WWW. | Expose teachers to the many different types of resources that exist on the WWW that are classroom appropriate. |
| Teachers are unaware of efficient search strategies to find materials and resources quickly. | Train teachers about resources and efficient search strategies. |
| Teachers lack skill in preparing and utilizing Web-based material in their classroom. | For those teachers with a real interest, provide and encourage training in the areas of how to develop, produce, and integrate Web-based material. |
| Perception | |
| Teachers have a limited and biased perception that the best use of the WWW is for the teachers or their students to "program" material to place on the WWW. | Educate teachers on other strategies for using the WWW in their classroom. |
| Teachers fear that if they choose to use the WWW that it will take a great deal of already limited time for planning and development. | Educate teachers to understand the type of resources that are available on the WWW and how to use efficient strategies for finding useful Web resources quickly. |
| Teachers fear that the computers will break down or things will go wrong in the middle of their lessons. | Administrators should budget technical support for teachers rather than rely on the teachers to have to troubleshoot and do systems administration as well. An analogy is that when teachers use the school car to transport students, they are not expected to maintain it as well. |
| Time | |
| A teacher's day is already taken up with tremendous amounts of responsibilities just to meet the minimum requirements of teaching and maintaining safety in the school. | WWW use should be viewed as another classroom resource. Choosing what and whether to use the WWW should be done in the same way as deciding to use other materials. This selection is a natural part of writing lessons plans rather than being an additional task to accomplish. |
| There is a high initial investment of time that teachers need to invest in learning new techniques to be used in the classroom. | Administrators should view learning the WWW in much the same manner as upgrading other skills and provide release time and training that would make teachers aware of the potential of the WWW as an instructional resource. |

School Content and WWW Resources

The second area of investigation was an examination of the school curriculum to determine how the link could be made between school curriculum and existing WWW resources. Primarily the National Education Standards were considered as representing school curriculum. The WWW was then examined to determine the breadth of resources that are available to teachers and students. Several challenges to teachers for incorporating the WWW into their classroom emerged from this analysis.

| School Context Realities | Recommendations |
|---|---|
| Curriculum | |
| Curriculum standards are changing to a more process and problem solving orientated curriculum. | Web-enhanced lessons can help teachers meet the changing curriculum standards by bringing problems anchored in reality to learners. Instructional resources that are designed specifically for the WWW should reflect these changing curriculum standards. |
| School curriculum is based on National Standards. | Any material that is put on the WWW for specific school use should be tied to the National Education Standards for easy linking back to school curriculum. |
| Not all teachers are aware of the National Standards, and in fact, are sometimes in conflict with understanding how their state and local standards fit into the scheme of things. | Whenever possible, WWW materials should also be tied to state and local education standards. |
| WWW Content | |
| Resources on the WWW contain a variety of materials including resources and people, databases, information, lesson plans, projects, student activities, tools, references and links, and tutorials. | This variety of resources makes it even more feasible to incorporate some aspects of the WWW in the classroom without it being experienced as an additional responsibility in an already overloaded schedule. Web-enhanced lessons should take into account the variety of materials to offer the most flexible strategies for WWW use. |

Teaching and Learning Processes

In this area of the investigation, contemporary perceptions about how children learn were examined, along with general classroom teaching practices. In addition, as a key part of this investigation, classroom uses of the WWW were studied to determine demonstrated strategies that were school tested. Finally, existing teacher training about WWW use in the classroom was assessed. This analysis has revealed several conditions that should be considered when developing Web-based or Web-enhanced classroom strategies and training for teachers.

| Teaching and Learning Process Realities | Recommendations |
|--|---|
| Classroom | |
| The classroom is being changed from a teacher-centered, to a learner-centered environment in which the children become active generators of knowledge rather than passive recipients of information. | Classroom strategies for using the WWW should take into account this new perception of the learning environment and the learning process. |

| Teaching and Learning Process Realities | Recommendations |
|--|---|
| Web Practices | |
| Interactivity on the WWW does not simply mean interaction between the learner and the computer information, but rather that interaction can be viewed in the broadest sense of creating learning partners with the global Web environment. | This broad definition of interactivity needs to be taken into account when any Web-enhanced learning models are created. |
| The WWW offers the classroom a global rather than a local view of information, jobs, science, mathematics and technology. | Anchoring local classrooms in real life activities through the WWW should be one model of its use in the classroom. |
| The Web offers information resources for demonstration in the classroom. | Using the WWW in the classroom does not always have to mean elaborate or extensive use. Using simple resources of the WWW to expand those that are available locally should be another consideration of WWW use in the classroom. |
| The WWW can be a source of information, or it can be a repository of teacher- or student-generated content or activities as well. | When students or teachers have the inclination to learn how to create content for the WWW, they should be encouraged to do so, however this should not be the only way the WWW is promoted for classroom use. |
| Teachers use a variety of effective teaching and learning strategies currently in their classrooms. | Strategies for using the WWW in the classroom should apply the most prevalent and effective learning strategies currently used by teachers and not be limited to only one approach. |
| Instruction About the Web | |
| Instruction exists that teaches teachers how to develop WWW materials. Less material exists which assists teachers in the integration of the WWW into the classroom. Often, however, these two types of Web use are not differentiated, resulting in the integration lessons being subsumed and lost under production lessons. | Simple to use models that stand alone as WWW integration strategies should be developed and disseminated. |

Final Recommendations

Teachers need to learn how to manage the WWW in their classrooms in a manner that does not take a great deal of additional time. Rather, the integration needs to be seamless in the normal planning activities required of teachers.

Classroom strategies of WWW use need to be developed that exemplify good teaching practices, are simple to use, and incorporate the variety of WWW resources that provide access to people and information. Training on the use of these strategies needs to include efficient WWW search methods so that the time required to find relevant material for the teachers' lessons will be decreased.

Administrators need to acknowledge the advantages of WWW use, and provide teachers with appropriate access, technical support, training, and time for training with this new classroom resource.

WWW developers need to fit their material into classroom teaching models that consider access, type of Web resources, and teaching and learning styles. These developers need to specify several options for teachers to use their materials given the realities of the classroom environment, content and teaching practice. The goal for developers should be to create material that provides the most flexibility and adaptability to the teachers, who are their ultimate customers.

APPENDIX A

AREAS OF STUDY AND ACCOMPANYING DIMENSIONS

1. ADMINISTRATIVE INFRASTRUCTURE

Supportive Administrators

| <input type="checkbox"/> High Involvement In Technology | <input type="checkbox"/> Partnerships | <input type="checkbox"/> Secretarial Support/ Administrative Support | <input type="checkbox"/> Encouraging Environment | <input type="checkbox"/> Administrative Use of Technology |
|--|---|--|---|---|
| <ul style="list-style-type: none"> Establishing technology objectives and technology budget | <ul style="list-style-type: none"> Partnering companies provide financial, computer, and time commitment | <ul style="list-style-type: none"> Secretarial support provided to help with grants, etc. Administrative support for budgeting resources | <ul style="list-style-type: none"> Administrative Support for change through incentives Administrators create encouraging environment | <ul style="list-style-type: none"> Administrator access to computer technology and integration into administrative functions |

Supportive Computer Technology and Services

| <input type="checkbox"/> State Level Technology Plan | <input type="checkbox"/> District Level Planning | <input type="checkbox"/> Technology Objectives in Place | <input type="checkbox"/> Technical Support |
|---|---|---|--|
| <ul style="list-style-type: none"> Detailed technology strategic plan at the state level | <ul style="list-style-type: none"> Technology development and implementation strategy in place for the school district | <ul style="list-style-type: none"> Technology objectives for equipment acquisition, use, and maintenance | <ul style="list-style-type: none"> Trained technical support personnel are available on-site to help teacher with computer-related problems or how to operate computers |

Support for Teachers

| <input type="checkbox"/> Release Time | <input type="checkbox"/> Substitute Teachers | <input type="checkbox"/> Teacher Training Plans | <input type="checkbox"/> Technology Integration in Curriculum | <input type="checkbox"/> Standards for Computer Competency |
|---|---|---|--|--|
| <ul style="list-style-type: none"> Teachers are granted time and pay to attend training sessions and meetings on using technology and the WWW in the classroom - may be excused of some duties (homeroom, bus, etc.) to pursue technology and for preparation time | <ul style="list-style-type: none"> Substitute teachers provided to cover teachers involved in learning or teaching other teachers about uses of technology in the classroom (teachers as technology ambassadors) | <ul style="list-style-type: none"> Technology training plans for teachers to place administrative stamp of approval and importance to the training | <ul style="list-style-type: none"> School curricula that establish the expectation that technology will be integrated rather than viewed as an add-on | <ul style="list-style-type: none"> Standards for teacher computer competency and incentives for exploring new ways of teaching. Software tools for teacher training and for teaching |

2. TECHNOLOGY INFRASTRUCTURE

Points of Connectivity

| | |
|--|---|
| <input type="checkbox"/> Instructional Rooms | <input type="checkbox"/> Non-Instructional Rooms |
| <ul style="list-style-type: none">• WWW access used for instruction such as classroom, computer labs, library, and media centers | <ul style="list-style-type: none">• WWW access used for other administrative purposes |

Number of Instructional Rooms Having Access to the Internet

| | | | | |
|---|--|--|--|--|
| <input type="checkbox"/> None | <input type="checkbox"/> One | <input type="checkbox"/> Two or Three | <input type="checkbox"/> Four | <input type="checkbox"/> Five or More |
| <ul style="list-style-type: none">• No instructional room having access to the Internet | <ul style="list-style-type: none">• One instructional room having access to the Internet | <ul style="list-style-type: none">• Two or three instructional rooms having access to the Internet | <ul style="list-style-type: none">• Four instructional rooms having access to the Internet | <ul style="list-style-type: none">• Five or more instructional rooms having access to the Internet |

Type of Network Connection

| | | | | |
|---|--|---|---|---|
| <input type="checkbox"/> Modem | <input type="checkbox"/> SLIP/PPP | <input type="checkbox"/> 56Kb | <input type="checkbox"/> ISDN | <input type="checkbox"/> T1 |
| <ul style="list-style-type: none">• Modems are typically used for dial-up connections over standard telephone lines | <ul style="list-style-type: none">• SLIP and PPP are two WWW protocols for making Internet connections (SLIP and PPP connections can be made at variable speeds) | <ul style="list-style-type: none">• 56Kb is a faster data transfer rate over a regular phone line | <ul style="list-style-type: none">• ISDN is fast digital phone line. The most common ISDN line is rated at 128Kb per second | <ul style="list-style-type: none">• T1 is a formatted digital signal at 1.544 megabits per second |

Existing Plan for Connection by the Year 2000

| | |
|--|---|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| <ul style="list-style-type: none">• Public schools having plan for Internet access | <ul style="list-style-type: none">• Public schools having no plan for Internet access |

Technical Support

| | |
|---|--|
| <input type="checkbox"/> Low to None | <input type="checkbox"/> High |
| <ul style="list-style-type: none">• Low availability• Reactive – Technical support occurs after a problem arises | <ul style="list-style-type: none">• Readily available• Active – Network and computers maintained for efficiency |

3. TEACHER FACTORS

Technical Skill

☐
Low

- Teacher does not know how to use a computer
- Teacher can use the computer a little but cannot integrate it into the classroom

☐
Medium

- Teacher has some skill in using the computer in the classroom
- Teacher can use the computer some and has the skill to integrate it into the classroom

☐
High

- Teacher has outstanding skills for using the computer in the classroom
- Teacher can use the computer and has the skill to integrate it into the classroom

Attitude and Motivation

☐
Positive

- Teacher has a positive attitude and high motivation for using the computer in the classroom

☐
Negative

- Teacher has a negative attitude and low motivation for using the computer in the classroom

Perception of Skills

☐
Low

- Teacher feels uncomfortable using technology
- Teacher can use the computer some but feels uncomfortable integrating it into the classroom

☐
Medium

- Teacher feels relatively comfortable using technology
- Teacher can use the computer some and feels relatively comfortable integrating it into the classroom

☐
High

- Teacher feels very comfortable using the computer
- Teacher can use the computer and feels very comfortable integrating it into the classroom

Perception of Administrative Support

☐
Low

- Teacher feels little administration support for using the computer in the classroom

☐
Medium

- Teacher feels some administration support for using the computer in the classroom

☐
High

- Teacher feels extensive support from administration for using the computer in the classroom

Assignment

☐
Elementary

- K-4 and 5-8 teaches elementary curriculum

☐
Secondary

- 9-12: teaches high school curriculum

Subject Area

☐
Generalist

- Teacher instructs many subject areas

☐
Specialist

- Teacher instructs one or two main topics

Time Teaching Science and Math

☐
Low

- Low: 0-20% of the day

☐
Medium

- Medium: 21-40% of the day

☐
High

- High: +41% of time the day

4. CURRICULUM

Curriculum Guidance

| <input type="checkbox"/> National Math and Science Education Standards | <input type="checkbox"/> Math Education Standards | <input type="checkbox"/> Science Curriculum | <input type="checkbox"/> State Education Standards |
|--|---|---|---|
| <ul style="list-style-type: none">• Science and Math curriculum is increasingly tied to National Education Standards | <ul style="list-style-type: none">• Math standards emphasize problem solving, communication, reasoning, and relationships | <ul style="list-style-type: none">• New science curriculum emphasizes concepts, theories, ideas, inquiry and interrelationships | <ul style="list-style-type: none">• Many states have their own interpretations of the National Standards• Some states have “special” emphasis as part of education standards, i.e., workplace skills |

Curriculum Support

| <input type="checkbox"/> Traditional Classroom Model | <input type="checkbox"/> Individual Course | <input type="checkbox"/> Interdisciplinary Curriculum | <input type="checkbox"/> Learner-Centered Model |
|---|--|--|--|
| <ul style="list-style-type: none">• Some feel that integration of the WWW will only be successful if it can be implemented into the current curriculum and teaching practices | <ul style="list-style-type: none">• WWW for individual school subjects taught as discrete units unrelated to other courses in the curriculum | <ul style="list-style-type: none">• Aspects of WWW such as its interconnected nature, search, and communication tools allow better integration of curriculum around themes and/or standards that are not necessarily subject based | <ul style="list-style-type: none">• Many feel it can be the catalyst for, and an integral part of, changing to a more learner-centered approach to teaching and learning |

Curriculum Resources

| <input type="checkbox"/> Finding and Evaluating Resources | <input type="checkbox"/> Types of Resources |
|---|---|
| <ul style="list-style-type: none">• Search Engines• Evaluation Tools | <ul style="list-style-type: none">• Lessons• Activities• Projects• Resources• References• Tools• Private for-profit subscription services |

5. EXISTING NASA MATERIALS

Databases

☐
Glossary

- Definitions of scientific terms

☐
Catalog

- Items for teacher to buy related to Space, Astronomy, Aeronautics, and Physical Sciences

☐
Archived Material

- Older items of interest to educators

Information and Resources

☐
Fact Sheets

- Details about often asked NASA questions

☐
News Releases

- Current NASA news stories

☐
Biographies

- Biographies of NASA employees (with interactive and collaborative components)

☐
Photos

- Pictures of pilots, planes, spaceships, planets, and areas of the Earth

☐
Workbooks

- Learner's workbooks

☐
Staff

- Live conversation with NASA staff

☐
Handbooks

- Handbooks containing technology issues

Lesson Plans

☐
K-4

- Lesson plans for elementary school curriculum

☐
5-8

- Lesson plans for middle school curriculum

☐
9-12

- Lesson plans for high school curriculum

Projects

☐
With NASA Personnel

- Schools projects with NASA personnel

☐
With NASA Data

- Projects with experimental NASA data

Student Activities

☐
K-4

- Activities for elementary school curriculum

☐
5-8

- Activities for middle school curriculum

☐
9-12

- Activities for high school curriculum

References and Links

☐
NASA Resources

- Educational resources from NASA

☐
Non-NASA Resources

- Educational resources not from NASA

Tools

☐
Searching Tools

- Search engines (tools) within NASA sites to help users find specific information

☐
Downloading Tools

- Downloading tools that can be used to access NASA resources, such as Adobe Acrobat, or plug-ins to access video or audio files

Tutorials

☐
Teachers

- Guidelines for teaching teachers with Web-based materials

☐
Students

- Guidelines for teaching students with Web-based materials

6. BEST PRACTICES OF USING THE WWW IN THE CLASSROOM

Use of the WWW During Instruction

| <input type="checkbox"/> Distance Learning | <input type="checkbox"/> WWW as Sole Delivery Mechanism in Classroom | <input type="checkbox"/> Computer w/Other Offline Activities | <input type="checkbox"/> Demonstration Tool |
|--|---|--|--|
| <ul style="list-style-type: none"> • No physical classroom • Student uses the WWW to access lesson instructions, for research, to complete activities and tests, and to submit work to instructor • Communication and feedback from instructor through e-mail or other online resources | <ul style="list-style-type: none"> • WWW in classroom or lab setting • Lesson instructions, activities, and content all delivered through the WWW | <ul style="list-style-type: none"> • Lesson introduction or instruction provided offline, students use the WWW primarily as a resource or for sharing results with others outside the classroom • Virtual field trips through video links to experts at zoos, museums, space centers, etc. | <ul style="list-style-type: none"> • The WWW is used as a presentation tool in the classroom, may have a projection device or students huddle around the computer for demonstration |

Interactivity with the World Wide Web

| <input type="checkbox"/> Access People | <input type="checkbox"/> Access Information | <input type="checkbox"/> Access People and Information | <input type="checkbox"/> Create and Generate Data | <input type="checkbox"/> Manipulate and Share Data |
|--|--|---|--|--|
| <ul style="list-style-type: none"> • Communicate or collaborate with people outside the classroom through e-mail, listservs, and chat rooms | <ul style="list-style-type: none"> • Research content areas • Find supporting graphics, sounds, etc. for lesson activities | <ul style="list-style-type: none"> • Collaborate and communicate with experts or peers • Ask questions, share data and information • Collaborate on research, lessons, learning activities | <ul style="list-style-type: none"> • Consolidate data into findings • Gather and report data for studies | <ul style="list-style-type: none"> • Take existing data from the WWW and manipulate it to support lesson objectives |

Types of World Wide Web Sites

| <input type="checkbox"/> Informational | <input type="checkbox"/> Instructional | <input type="checkbox"/> Learning |
|--|--|---|
| <ul style="list-style-type: none"> • Site provides reference information that can be used to complete lessons • No planned active interaction with site other than searching and reading | <ul style="list-style-type: none"> • Lesson plans or activity instructions • May provide models, examples of expected outcomes | <ul style="list-style-type: none"> • Site designed to enhance learning, cognitive processing, interactive investigation, and manipulation of content |

Origination of Sites

| <input type="checkbox"/> Teacher Created | <input type="checkbox"/> Student Created | <input type="checkbox"/> Authority Created | <input type="checkbox"/> General Public |
|--|---|---|--|
| <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites to provide instruction for students | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites to demonstrate understanding of lesson content | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites by an authority or expert in the topic content • Content is generally considered to be accurate | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites by general public. • No verification of accuracy of site topic content |

7. TEACHER TUTORIALS

WWW Producer



High Producer

- Creates content pages
- Manages Web sites
- Writes code
- Creates interactive sites
- Uses multiple media types
- Requires less internal initiative



Low Producer

- Produces single medium sites
- Creates passive, non-interactive sites
- Requires more internal initiative

WWW Integrator



High Integrator

- Identifies multiple WWW resources
- Uses e-mail
- Facilitates communication
- Moderate electronic discussion groups
- Designs interactions
- Creates interactive environments
- Uses multiple media types



Low Integrator

- Uses single or few WWW resources
- Uses the WWW resources as demonstration sites

8. LEARNING THEORIES AND TEACHING PRACTICES

Behavioral Perspectives

| | |
|---|--|
| <input type="checkbox"/> Operant Conditioning <ul style="list-style-type: none"> • Learning is measured in terms of observable behaviors, these behaviors can be changed with different kinds of reinforcement | <input type="checkbox"/> Applied Behavior Analysis <ul style="list-style-type: none"> • Uses principles of operant conditioning |
|---|--|

Cognitive Perspectives

| | | | | |
|--|--|---|--|--|
| <input type="checkbox"/> Constructivism <ul style="list-style-type: none"> • Based on the idea that learning is a process of individual "meaning-making" | <input type="checkbox"/> Generative Learning <ul style="list-style-type: none"> • Learning can be fostered by allowing students to generate their own inferences, analogies, organizational frameworks, etc. for material | <input type="checkbox"/> Self-Regulated Learning <ul style="list-style-type: none"> • An integration of ideas from metacognition, motivation, and learning behaviors, SRL strives to foster learners who are active agents in their learning process | <input type="checkbox"/> Metacognition <ul style="list-style-type: none"> • Metacognition means "knowing about knowing" • Metacognitive strategies can be useful in the learning process | <input type="checkbox"/> Concept Learning <ul style="list-style-type: none"> • Examines how learners create understanding of new concepts, also how old concepts are revised or updated |
| <input type="checkbox"/> Dual Coding Theory <ul style="list-style-type: none"> • Describes the information in long-term memory in terms of verbal and nonverbal representations | <input type="checkbox"/> Schema Theory <ul style="list-style-type: none"> • Information in long-term memory in terms of a semantic network with related information grouped in schemata | <input type="checkbox"/> Problem Solving <ul style="list-style-type: none"> • Examines the problem solving process, delineating between well-structured and ill-structured problems | <input type="checkbox"/> Elaboration Theory <ul style="list-style-type: none"> • Learning is a process of elaborating on existing knowledge | <input type="checkbox"/> Tetrahedral Model <ul style="list-style-type: none"> • Describes the learning process in terms of four interrelated factors: the learner, the teacher, the task, and the environment |

Motivational Perspectives

| | | | |
|--|---|---|---|
| <input type="checkbox"/> Flow Theory <ul style="list-style-type: none"> • Motivation is highest when a learner is at a certain level of challenge | <input type="checkbox"/> Attribution Theory <ul style="list-style-type: none"> • Motivation is largely determined by the factors to which a student attributes success or failure (i.e. attributing success to effort) | <input type="checkbox"/> Achievement Goal Theory <ul style="list-style-type: none"> • Motivation can be described in terms of students' achievement goals. Students with performance goals are motivated by extrinsic factors (grades, praise); students with mastery goals are intrinsically motivated by the material itself | <input type="checkbox"/> Expectancy-Value Theory <ul style="list-style-type: none"> • Motivation is largely determined by 1) the extent to which a student expects to be successful on a task, and 2) the value the student places on the task |
|--|---|---|---|

Sociocognitive Perspectives

| | |
|--|---|
| <input type="checkbox"/> Social Development <ul style="list-style-type: none"> • Learning takes place in the social context of our culture and can be fostered by interactions between a student and an adult teacher | <input type="checkbox"/> Cooperative Learning <ul style="list-style-type: none"> • It is important for groups to have a common goal and to foster individual accountability and group accountability to meet that goal |
|--|---|

Developmental Theories

| | |
|---|--|
| <input type="checkbox"/> Stage Theories <ul style="list-style-type: none"> • Learning occurs in childhood through progressive stages of development; mastery of one stage is necessary before a learner can move to the next stage | <input type="checkbox"/> Non-Stage Theories <ul style="list-style-type: none"> • Learning in childhood occurs by a process of gradual non-stage knowledge acquisition |
|---|--|

APPENDIX B SUPPORTING EVIDENCE AND EXAMPLES

1. ADMINISTRATIVE INFRASTRUCTURE

Supportive Administrators

| Level/Factor | Description | Source |
|---|--|--|
| High Involvement in Technology | <ul style="list-style-type: none"> Establishing technology objectives and technology budget | <ul style="list-style-type: none"> Skyline Elementary School, Daly City, California www.ed.gov/pubs/EdReformStudies/EdTech/skyline.html Pfeiffer Elementary School, San Antonio, Texas www.san-antonio.isd.tenet.edu/SCHOOL/159/Home.html |
| Partnerships | <ul style="list-style-type: none"> Partnering companies providing financial support, equipment, and time commitment | <ul style="list-style-type: none"> Bell / Crenshaw, Los Angeles, California (R. Beaty, personal interview, March 1997). West High School, Columbus, Ohio www.ed.gov/pubs/EdReformStudies/EdTech/west_ascot.html |
| Secretarial and Administrative Support | <ul style="list-style-type: none"> Secretarial support provided to help with grants, etc. Administrative support for budgeting resources | <ul style="list-style-type: none"> ShareNet |
| Encouraging Environment | <ul style="list-style-type: none"> Administrative support for change through incentives Administrators create encouraging environment | <ul style="list-style-type: none"> Philadelphia www.philsch.k12.pa.us San Francisco http://nisus.sfusd.k12.ca.us/EdTech/EdTech.html |
| Administrative Use of Computer Technology | <ul style="list-style-type: none"> Administrator access to computer technology and integration into administrative functions | <ul style="list-style-type: none"> Champlain Valley High School, Hinesburg, Vermont www.cvu.cssd.k12.vt.us/k12tech |

Supportive Computer Technology and Services

| Level/Factor | Description | Source |
|-------------------------------------|--|--|
| State Level Technology Plan | <ul style="list-style-type: none"> Detailed technology strategic plan at the state level – 0 | <ul style="list-style-type: none"> Mississippi www.mde.state.ms.us/oet.htm Michigan www.mde.state.mi.us/techplan/TechPlan.html Colorado www.cde.state.co.us |
| District Level Implementation Plans | <ul style="list-style-type: none"> Technology development and implementation strategy in place for a school district | <ul style="list-style-type: none"> Bellingham Public Schools, Bellingham, Washington http://bham.wednet.edu/technology.htm Big Rapids Public Schools, Michigan gopher://gopher.msstate.edu.70/00/Online_services/nctp/big_rapids.mi.txt Kenai Peninsula School District, Alaska |
| Technology Objectives in Place | <ul style="list-style-type: none"> Technology objectives for equipment acquisition, use, and maintenance | <ul style="list-style-type: none"> Millbury Public Schools, Millbury, Massachusetts www.millbury.k12.ma.us/school/techplan |
| Technical Support | <ul style="list-style-type: none"> Trained technical support personnel are available on-site to help teacher with computer-related problems or how to operate computers | <ul style="list-style-type: none"> Community High School, Ann Arbor, Michigan http://www.ncrel.org/sdrs/areas/issues/methods/technlgy/te300.htm |

Support for Teachers

| Level/Factor | Description | Source |
|--------------------------------------|--|---|
| Release Time | <ul style="list-style-type: none"> Teachers are granted time and pay to attend training sessions and meetings on using technology and the WWW in the classroom; may be excused of some duties (homeroom, bus, etc.) to pursue technology and for preparation time | <ul style="list-style-type: none"> Philadelphia Area School District, Philadelphia, Pennsylvania www.philsch.k12.pa.us Skyline Elementary School, Daly City, California www.ed.gov/pubs/EdReformStudies/EdTech/skyline.html |
| Substitute Teachers | <ul style="list-style-type: none"> Substitute teachers provided to cover classes of teachers involved in learning or teaching other teachers about uses of technology in the classroom (teachers as technology ambassadors) | <ul style="list-style-type: none"> West High School, Columbus, Ohio www.ed.gov/pubs/EdReformStudies/EdTech/west_ascot.html Charlotte School District, Charlotte, North Carolina http://www.cms.k12.nc.us |
| Teacher Training Plans | <ul style="list-style-type: none"> Technology training plans for teachers to place administrative stamp of approval and importance to the training | <ul style="list-style-type: none"> Ohio. www.ode.ohio.gov San Jose School District, San Jose, California http://sccoe.k12.ca.us.4382home.htm |
| Technology Integration in Curriculum | <ul style="list-style-type: none"> School curricula that establish the expectation that technology will be integrated rather than viewed as an add-on | <ul style="list-style-type: none"> Dallas, Texas http://www.dallsa.isd.tenet.edu/dallaspublicschools.html Chicago, Illinois http://aix.cps.edu |
| Standards for Computer Competency | <ul style="list-style-type: none"> Standards for teacher computer competency and incentives for exploring new ways of teaching Software tools for teacher training and for teaching | <ul style="list-style-type: none"> California www.cde.ca.gov Vermont http://www.cvu.cssd.k12.vt.us/k12tech |

California Board of Education (www.cde.ca.gov)

- Master Plan for Education Technology, mandated by California legislature, support for teachers to learn technology
- Ancient World – New teaching tool online, multimedia course adopted for use in all California schools who want it and can pay for it (25% discount), collaboration with private sector

Colorado

- Colorado Technology Plan (www.cde.state.co.us) Master Plan to integrate technology; mandate from state

Mississippi

- Plan for integrating technology (www.mde.state.ms.us/oet.htm) State plan including administrative support and directives

Michigan

- Michigan's overall technology plan (www.mde.state.mi.us/techplan/TechPlan.html)

Big Rapids Public Schools, Michigan (gopher://gopher.msstate.edu:70/00/Online_services/nctp/big.rapids.mi.txt)

- An example of a local school district plan based on state directives

Louden County Public Schools, Virginia (gopher://gopher.msstate.edu:70/00/Online_services/netp/louden.va.txt)

- Local school district technology plan

Bellingham Public Schools, Bellingham, Washington (<http://bham.wednet.edu/technology.htm>)

- School district technology plan

Millbury Public Schools, Millbury, Massachusetts (www.millbury.k12.ma.us/school/techplan)

- District level technology plan

Champlain Valley Union High School, Hinesburg, Vermont (www.cvu.cssd.k12.vt.us/k12tech)

- School level strategic plan
- Supporting administrators through access and training

Philadelphia Area School District, Philadelphia, Pennsylvania (www.philsch.k12.pa.us)

- Laboratory schools collaboration among teachers, teacher visits to other teacher's classrooms to see how they are incorporating technology, highly qualified replacement teachers to fill-in for teachers learning, collaborating, and visiting

Skyline Elementary School, Daly City, California (www.ed.gov/pubs/EdReformStudies/EdTech/skyline.html)

- Core of teachers with administrative support found funding and learned about technology; they helped train other teachers. Teachers were given freedom to develop a new teaching model integrating technology

San Francisco United School District, San Francisco, California (<http://nisus.sfusd.k12.ca.us/EdTech/EdTech.html>)

- Importance of an administrative "Education Technology Team" for success

Ohio – (www.ode.ohio.gov)

- State level plan to be used as a guide for local integration of technology

Pfeiffer Elementary School, San Antonio, Texas, went to Southwestern Bell offices and asked for help in linking the school (www.san-antonio.isd.tenet.edu/SCHOOL/159/Home.html)

- Southwestern Bell immediately offered \$15,000 in equipment and \$42,000 in labor to do the job
- Principal very motivated
- Computers and WWW have increased student motivation
- Results on state-wide achievement tests have greatly improved
- School is mostly low-income students and in 1992 testing results were very poor
- Now 100% of students passed the reading tests and other test results have improved dramatically

West High School, Columbus, Ohio (www.ed.gov/pubs/EdReformStudies/EdTech/west_ascot.html)

- An Apple Classroom of Tomorrow School. Innovative computer use. Collaboration among teachers

Bell High School, Los Angeles, California (9th –12th grade, 4000 students, economically disadvantaged inner city school, no outside access to computers) and Crenshaw High School, Los Angeles, California (9th –12th grade, 2000 students, economically disadvantaged inner city school, no outside access to computers) (R. Beaty, personal interview, March 1997)

- Cascading technical training from core teachers to others (Having a core group of committed teachers seems to be a key. Being able to help train others and talk about successes is important.)
- Given administrative support for teachers to write grants, take time to attend training
- As money came in, more teachers became involved
- Teachers meet after class hours (Vice principal attended the meetings - administrative support)
- Community relationships

- University of Southern California (USC) outreach to fund and maintain T1 lines, administrative support provided for teachers to meet with outreach supporters, National Science Foundation (NSF) grants
- Economic and support infrastructure, cut a deal with USC to be provider for all schools, fees split across all schools to lower payments once free provider service ends
- Developed cost/benefit analysis to show that continued use of WWW connection will decrease administrative costs of passing school records between schools as students move
- Public Utility Commission (PUC) offers standardized prices to education facilities (Importance of administrative support for partnerships and “problem solving” the economic issues. USC will eventually be the service provider for schools and receive income.)

Marlborough School, Los Angeles, California

- Well funded, 7th –12th grade, 500 students 80% with home access to computers, 150 networked computers, private school, not a lot of administrative involvement
- Top down did not necessarily work well
- Lack of involvement from administrators
- No incentive for teachers in control group to learn how to use
- A good example of technology availability but poor integration because of a lack of administration support

2. TECHNOLOGY INFRASTRUCTURE

Points of Connectivity

| Level/Factor | Description | Source |
|-------------------------|---|---|
| Instructional Rooms | <ul style="list-style-type: none"> Internet access used for instruction such as classroom, computer labs, library, and media centers | <ul style="list-style-type: none"> http://www.ed.gov/NCES/pubs/97944.html |
| Non-Instructional Rooms | <ul style="list-style-type: none"> Internet access used for other purposes | |

Number of Instructional Rooms Having Access to the Internet

| Level/Factor | Description | Source |
|--------------|--|---|
| None | <ul style="list-style-type: none"> No instructional room having access to the Internet | <ul style="list-style-type: none"> http://www.ed.gov/NCES/pubs/97944.html |
| One | <ul style="list-style-type: none"> One instructional room having access to the Internet | |
| Two or Three | <ul style="list-style-type: none"> Two or three instructional rooms having access to the Internet | |
| Four | <ul style="list-style-type: none"> Four instructional rooms having access to the Internet | |
| Five or more | <ul style="list-style-type: none"> Five or more instructional rooms having access to the Internet | |

Type of Network Connection

| Level/Factor | Description | Source |
|--------------|--|---|
| Modem | <ul style="list-style-type: none"> Modems are typically used for dial-up connections over standard telephone lines | <ul style="list-style-type: none"> http://www.ed.gov/NCES/pubs/97944.html |
| SLIP/PPP | <ul style="list-style-type: none"> SLIP and PPP are two WWW protocols for making Internet connections (SLIP and PPP connections can be made at variable speeds) | |
| 56Kb | <ul style="list-style-type: none"> 56Kb is a faster data transfer rate over a regular phone line | |
| ISDN | <ul style="list-style-type: none"> ISDN is fast digital phone line. The most common ISDN line is rated at 128Kb per second | |
| T1 | <ul style="list-style-type: none"> T1 is a formatted digital signal at 1.544 megabits per second | |

Existing Plan for Connection by the Year 2000

| Level/Factor | Description | Source |
|--------------|---|---|
| Yes | <ul style="list-style-type: none"> Public schools having plan for Internet access | <ul style="list-style-type: none"> http://www.ed.gov/NCES/pubs/97944.html |
| No | <ul style="list-style-type: none"> Public schools having no plan for Internet access | |

Technical Support

| Level/Factor | Description | Source |
|--------------|--|--|
| Low to None | <ul style="list-style-type: none"> Low availability Reactive – Technical support occurs after a problem arises | <ul style="list-style-type: none"> R. Beaty, personal interview and e-mails, April 1997 |
| High | <ul style="list-style-type: none"> Readily available Active – Network and computers maintained for efficiency | |

3. TEACHER FACTORS

Technical Skill

| Level/Factor | Description | Source |
|--------------|---|---|
| Low | <ul style="list-style-type: none"> • Teacher does not know how to use a computer • Teacher can use the computer a little but cannot integrate it into the classroom | <ul style="list-style-type: none"> • 34% now using WWW to assist in teaching (Sun Micros Systems, 1996 - telephone survey-5076) • 35% low |
| Medium | <ul style="list-style-type: none"> • Teacher has some skill using the computer in the classroom • Teacher can use the computer somewhat and has the skill to integrate it into the classroom | <ul style="list-style-type: none"> • 50% medium |
| High | <ul style="list-style-type: none"> • Teacher has an outstanding skill for using the computer in the classroom • Teacher can use the computer and has the ability to integrate it into the classroom | <ul style="list-style-type: none"> • 20% high (Kendall, informal survey, March 1997) |

Attitude and Motivation

| Level/Factor | Description | Source |
|--------------|---|--|
| Positive | <ul style="list-style-type: none"> • Teacher has a positive attitude and high motivation for using the computer in the classroom | <ul style="list-style-type: none"> • 90% of Pre-service teachers are positive about using technology (Kendall, informal survey, March 1997) • 93% say WWW is good (Sun Micros Systems, 1996 – telephone survey-507) • 56% say computer is very effective tool; 40% say somewhat effective (Sun Micros Systems, 1996 - telephone survey-507) • 33% Mt. Nittany Middle School teachers use WWW in lesson planning; 22% use WWW in their classroom (Tiracorda, informal survey, March 1997) • 100% of pre-service teachers said computers were useful (Kendall, informal survey, March 1997) |
| Negative | <ul style="list-style-type: none"> • Teacher has a negative attitude and low motivation for using the computer in the classroom | |

Perception of Skills

| Level/Factor | Description | Source |
|--------------|---|---|
| Low | <ul style="list-style-type: none"> Teacher feels uncomfortable using the computer Teacher can use the computer some but feels uncomfortable integrating it into the classroom | <ul style="list-style-type: none"> 72% unconfident (Sun Micros Systems, 1996 - telephone survey-507) Self-rating of computer skills: 28% low (Kendall, informal survey, March 1997) Thought computers were difficult: 20% high (Kendall, informal survey, March 1997) Level of comfort: 25% low |
| Medium | <ul style="list-style-type: none"> Teacher feels relatively comfortable using the computer Teacher can use the computer some and feels relatively comfortable integrating it into the classroom | <ul style="list-style-type: none"> Self-rating of computer skills 57% medium (Kendall, informal survey, March 1997) Thought computers were difficult: 50% medium (Kendall, informal survey, March 1997) Level of comfort: 43% medium |
| High | <ul style="list-style-type: none"> Teacher feels very comfortable using the computer Teacher can use the computer and feels very comfortable integrating it into the classroom | <ul style="list-style-type: none"> 28% confident (Sun Micros Systems, 1996 - telephone survey-507) Thought computers were difficult: 35% low (Kendall, informal survey, March 1997) Level of comfort: 25% high; 26% were involved in WWW based projects (Langley Teacher Resource Center, focus group, May 1997) |

Perception of Administrative Support

| Level/Factor | Description | Source |
|--------------|---|---|
| Low | <ul style="list-style-type: none"> Teacher feels a lack of support from administration for using the computer in the classroom | <ul style="list-style-type: none"> 11% have Internet in their classroom (National Center for Educational Statistics (NCES) U.S. Department of Education Fast Response Survey System (FRSS) "Advanced Teleconference in Public Schools K-12" FRSS 51, NCES 95-731; "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, 95" FRSS 57 NCES 96-854; "Survey on Advanced Telecommunications in U.S. Public Schools, Fall 1996" FRSS 61, 1996.) 100% of Mt. Nittany Middle School teachers have Internet in their classroom (Tiracorda, informal survey, March 1997) |
| Medium | <ul style="list-style-type: none"> Teacher feels some administration support for using the computer in the classroom | |
| High | <ul style="list-style-type: none"> Teacher feels extensive support from administration for using the computer in the classroom | |

Assignment

| Level/Factor | Description | Source |
|--------------|---|---|
| Elementary | <ul style="list-style-type: none"> • K-4 and 5-8 teaches elementary curriculum | <ul style="list-style-type: none"> • 3,088,000 total U.S. teachers • 1,576,00 public elementary teachers • 1,103,000 public secondary teachers • 2,525,199 total public school teachers • 63,572 Total number of public elementary schools • 23,046 Total number of public secondary schools <p>(National Center for Educational Statistics (NCES) U.S. Department of Education Fast Response Survey System (FRSS) "Advanced Teleconference in Public Schools K-12" FRSS 51, NCES 95-731; "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, 95" FRSS 57 NCES 96-854; "Survey on Advanced Telecommunications in U.S. Public School, Fall 1996" FRSS 61, 1996.)</p> |
| Secondary | <ul style="list-style-type: none"> • 9-12: teaches high school curriculum | |

Subject Area(s)

| Level/Factor | Description | Source |
|--------------|--|--|
| Generalist | <ul style="list-style-type: none"> • Teacher instructs many subject areas | <ul style="list-style-type: none"> • 14.5% teach math • 13.3% teach science <p>(National Center for Educational Statistics (NCES) U.S. Department of Education Fast Response Survey System (FRSS) "Advanced Teleconference in Public Schools K-12" FRSS 51, NCES 95-731; "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, 95" FRSS 57 NCES 96-854; "Survey on Advanced Telecommunications in U.S. Public School, Fall 1996" FRSS 61, 1996.)</p> |
| Specialist | <ul style="list-style-type: none"> • Teacher instructs one or two main topics | |

Time Spent Teaching Science and Math

| Level/Factor | Description | Source |
|--------------|---|--|
| Low | <ul style="list-style-type: none"> • 0-20% of time during the day | <ul style="list-style-type: none"> • 0-20% of day = science • 0-40% of day = math • (Elem. Pre-service teachers - Kendall, informal survey, March 1997) |
| Medium | <ul style="list-style-type: none"> • 21-40% of time during the day | |
| High | <ul style="list-style-type: none"> • 41%-plus of time during the day | |

4. CURRICULUM

Curriculum Guidance

| Level/Factor | Description | Source |
|---|---|---|
| National Math and Science Education Standards | <ul style="list-style-type: none"> Science and math curriculum is increasingly tied to National Education Standards | <ul style="list-style-type: none"> Goals 2000 |
| Math Standards | <ul style="list-style-type: none"> Math Education Standards emphasize problem solving, communication, reasoning, and relationships | <ul style="list-style-type: none"> National Council of Teachers of Mathematics. Curriculum and Evaluation Standards for School Mathematics. Reston, Virginia: National Council of Teachers of Mathematics, 1989. http://www.enc.org/reform/journals/ENC2280/nf_280dtoc1.htm |
| Science Curriculum | <ul style="list-style-type: none"> New science curriculum emphasizes concepts, theories, ideas, inquiry, and interrelationships | <ul style="list-style-type: none"> National Science Education Standards (Content Standards). http://www.nap.edu/readingroom/books/nses/html/6a.html |
| State Education Standards | <ul style="list-style-type: none"> Many states have their own interpretations of the National Education Standards Some states have "special" emphasis as part of education standards, i.e. Workplace Skills | <ul style="list-style-type: none"> State References for Standards Alaska. http://www.educ.state.ak.us/ContentStandards/Home.html Colorado. http://www.cde.state.co.us/ftpcde.html Delaware. http://www.udel.edu/dpi/stand.html Florida. http://www.firn.edu/doc/curric/ Illinois. http://www.isbe.state.il.us/standards Indiana. http://ideanet.doe.state.in.us/science Kansas. http://www.ksbe.state.ks.us/outcomes/qpa.html Kentucky. http://www.kde.state.ky.us/caa/expect.html Louisiana. http://www.doe.state.la.us/ Maryland. http://www.msde.state.md.us/msde/outcomes/out.html Missouri. http://services.dese.state.mo.us/standards New Jersey. http://www.injersey.com/Education/NJDOE/ New York. http://www.nysed.gov/home/facmtg.currinfo.html North Carolina. http://www.dpi.state.nc.us/Cirriculum/crrclmmtrx.html Ohio. http://www.ode.ohio.gov/http://www/standards/standards.html Texas. http://www.tea.state.tx.us:70/0/teks/index.html Vermont. http://www.state.vt.us/educ/stand/ Virginia. http://www.pen.kiz.va.us/go/Sols/ Washington. http://e51.wednet.edu/EALR/ealr-note.html Wisconsin. http://badger.state.wi.us/agencies/dpi/standards/ Mendocino School District http://www.mcn.org/ed/curliv/Units/list.html. -- Example local integration of state (California) curriculum frameworks |

Curriculum Support

| Level/Factor | Description | Source |
|------------------------------|---|--|
| Traditional classroom model | <ul style="list-style-type: none"> Some feel that integration of technology will only be successful if it can be implemented into the current curriculum and teaching practices | <ul style="list-style-type: none"> Sellers and Robichaux http://sunsite.auc.dk/RFC/rfc/rfc1941.html |
| Individual Course | <ul style="list-style-type: none"> WWW for individual school subjects taught as discrete units unrelated to other courses in the curriculum | <ul style="list-style-type: none"> WWW Schoolhouse Resources by Discipline |
| Interdisciplinary Curriculum | <ul style="list-style-type: none"> Curriculum is supported by the very interconnected nature of the web; search and communication tools allow better integration of curriculum around themes and/or standards that are not necessarily subject based | <ul style="list-style-type: none"> Post, et al. (1997). Interdisciplinary Approaches to Curriculum. New York, Simon and Schuster. |
| Learner-Centered Model | <ul style="list-style-type: none"> Many feel it can be the catalyst for, and an integral part of, changing to a more learner-centered approach to teaching and learning | <ul style="list-style-type: none"> Saturn School of Tomorrow Frank Paul Elementary School Los Angeles Open Charter School |

Curriculum Resources

| Level/Factor | Description | Source |
|----------------------------------|--|--|
| Finding and Evaluating Resources | <ul style="list-style-type: none"> Search Engines Evaluation Tools | <ul style="list-style-type: none"> Oasis. http://www-co-cas.colorado.edu/oasis/oasis_search.html BlueWeb'n http://www.kn.pacbell.com/wired/bluewebn Explorer http://unite2.tisl.ukans.edu/ North Carolina Curriculum Matrix. http://www.dpi.state.nc.us/Curriculum/crcclmmatrix.html http://refserver.lib.vt.edu/libinst/critTHINK.HTM - Bibliography on Evaluating Internet Resources, Nicole Auer, Virginia Polytechnic Institute and State University Brandt, D. Scott http://www.infoday.com/cilmag/may/cilmag.htm Evaluating Information on the Internet http://milton.mse.jhu.edu:8001/research.education/net.html Evaluating information found on the Internet, Elizabeth Kirk, Johns Hopkins University http://itech1.coe.uga.edu/Faculty/gwilkinson/webeval.html Evaluating the Quality of Internet Information Sources http://www.stemnet.nf.ca/Curriculum/Validate/ Internet Source Validation Project http://www.science.widener.edu/~withers/webeval.htm Teaching Critical Evaluation Skills for World Wide Web Resources Widener University CyberGuide http://www.cyberbee.com/guidel.html Kathy Schrock's Guide for Educators http://www.capecod.net/schrockguide/eval.htm |
| Types of Resources | <ul style="list-style-type: none"> Lessons Activities Projects Resources References Tools Private, for-profit subscription services | <ul style="list-style-type: none"> Electronic Emissary Sample organized links CCCnet http://www.cccnet.com Scholastic Network http://scholastic.com Classroom Connect http://www2.classroom.net |

5. EXISTING NASA MATERIALS

Databases

| Level/Factor | Description | Source |
|-------------------|--|--|
| Glossary | • Definitions of scientific terms | • http://quest.arc.nasa.gov/livefrom/hst.html (Hubble Space Telescope glossary) |
| Catalogue | • Items for teacher to buy related to space, astronomy, aeronautics, and physical sciences | • http://trc.dfrc.nasa.gov/catalogindex.html • http://trc.dfrc.nasa.gov/catalog/printmat.html |
| Archived Material | • Older items of interest to educators | • ftp://ftp.jpl.nasa.gov/pubeducator |

Information and Resources

| Level/Factor | Description | Source |
|---------------|---|--|
| Facts Sheet | • Details about often asked NASA questions | • http://spacelink.msfc.nasa.gov/html/Spacelink.Frequently.Asked.Questions.html • http://spacelink.msfc.nasa.gov/Spacelink.Frequently.Asked.Questions/FAQ-Astronauts |
| News Releases | • Current NASA news stories | • http://spacelink.msfc.nasa.gov/NASA.News/NASA.News.Releases/ |
| Biographies | • Biographies of NASA employees (with interactive and collaborative components) | • http://www.nasa.gov/hqpao/bios/ |
| Photos | • Pictures of pilots, planes, spaceships, planets, and areas of the Earth | • http://www.dfrc.nasa.gov/PhotoServer/ |
| Workbooks | • Learner workbooks | • http://trc.dfrc.nasa.gov/handbook/index.html • http://www.ncsa.uiuc.edu/General/Internet/WWW/HTML.Primer.html |
| Staff | • Live conversation with NASA staff | • listmanager@quest.arc.nasa.gov |
| Handbooks | • Handbooks containing technology issues | • http://trc.dfrc.nasa.gov/handbook/concerns.html • http://trc.dfrc.nasa.gov/dryden.html |

Lesson Plans

| Level/Factor | Description | Source |
|--------------|---|---|
| K-4 | • Lesson plans for elementary school curriculum | • http://trc.dfrc.nasa.gov/shape/TCU/bblogic.htm |
| 5-8 | • Lesson plans for middle school curriculum | • http://spacelink.msfc.nasa.gov/Instructi..matics/Measuring.with.Triangulation.7-12 |
| 9-12 | • Lesson plans for high school curriculum | • http://trc.dfrc.nasa.gov/shape/TCU/ratio1.htm |

Projects

| Level/Factor | Description | Source |
|------------------------------|--|---|
| Projects with NASA Personnel | • Schools projects with NASA personnel | • http://trc.dfrc.nasa.gov/education.html |
| Projects with NASA Data | • Projects with experimental NASA data | • http://www.mtwilson.edu/science/TIE |

Student Activities

| Level/Factor | Description | Source |
|--------------|---|---|
| K-4 | • Activities for elementary school curriculum | • http://www.rspac.ivv.nasa.gov/nasa/fun/fun_index.shtml |
| 5-8 | • Activities for middle school curriculum | • http://trc.dfrc.nasa.gov/shape/TCU/jnforce1.Htm |
| 9-12 | • Activities for high school curriculum | • http://tommy.jsc.nasa.gov/~woodfill/SPACEED/SEHTML/earlysf.html |

References and Links

| Level/Factor | Description | Source |
|--------------------|---------------------------------------|---|
| NASA Resources | • Educational resources from NASA | • http://spacelink.msfc.nasa.gov/ |
| Non-NASA Resources | • Educational resources not from NASA | • http://fuzine.mt.cs.cmu.edu/mlm/lycos-home.html • http://www.webcrawler.com • http://www.cs.colorado.edu/home/mcbryan/www.html |

Tools

| Level/Factor | Description | Source |
|-------------------|--|---|
| Searching Tools | • Search engines (tools) within NASA sites to help users find specific information | • http://www.aldea.com/bluepages/tool.html |
| Downloading Tools | • Downloading tools that can be used to access NASA resources, such as Adobe Acrobat, or plug-ins to access video or audio files suggested by NASA | • http://www.Adobe.com/prodindex/acrobat/readstep.html |

Tutorials

| Level/Factor | Description | Source |
|--------------|---|--|
| Teachers | • Guidelines for teaching teachers with Web-based materials | • http://trc.dfrc.nasa.gov/handbook/index.html • http://www.rspac.ivv.nasa.gov/nasa/education/reference/main.html |
| Students | • Guidelines for teaching students with Web-based materials | • http://observe.ivv.nasa.gov/nasa/education/tools/stepby/hwtolan2.html |

Web Sites Visited

The Web sites below were visited between February 1997 and May 1997 while doing research for this paper. Some of these sites may have been revised in the time that has elapsed since then, so may no longer be accessible.

Dryden sites visited:

<http://trc.dfrc.nasa.gov/education.html>
<http://trc.dfrc.nasa.gov/catalog/index.html>
<http://trc.dfrc.nasa.gov/catalog/printmat.html>
<http://trc.dfrc.nasa.gov/shape/TCU/jnforce1.htm>
<http://trc.dfrc.nasa.gov/shape/TCU/ratio1.htm>
<http://trc.dfrc.nasa.gov/shape/TCU/bblogic.htm>
<http://trc.dfrc.nasa.gov/handbook/concerns.html>
<http://trc.dfrc.nasa.gov/handbook/index.html>
<http://trc.dfrc.nasa.gov/dryden.html>
<http://www.dfrc.nasa.gov/PhotoServer/>

Other NASA sites visited:

listmanager@quest.arc.nasa.gov
<http://quest.arc.nasa.gov/livefrom/hst.html>
<http://spacelink.msfc.nasa.gov/html/Spacelink.Frequently.Asked.Questions.html>
<http://spacelink.msfc.nasa.gov/Spacelink.Frequently.Asked.Questions/FAQ-Astronauts>
<http://spacelink.msfc.nasa.gov/NASA.News/NASA.News.Releases/>
<http://spacelink.msfc.nasa.gov/Instructi...ectronic.Resources.for.Science.Educators>
<http://spacelink.msfc.nasa.gov/Intructi...matics/Measuring.with.Triangulation.7-12>
http://www.rspac.ivv.nasa.gov/nasa/fun/fun_index.shtml
<http://www.rspac.ivv.nasa.gov/nasa/education/reference/main.html>
<http://observe.ivv.nasa.gov/nasa/education/tools/stepby/hwtolan2.html>
<ftp://ftp.jpl.nasa.gov/pub/educator/>
<http://www.nasa.gov/hqpao/bios/>
<http://tommy.jsc.nasa.gov/~woodfill/SPACEED/SEHHTML/earlysf.html>

Non-NASA sites visited:

<http://fuzine.mt.cs.cmu.edu/mlm/lycos-home.html>
<http://www.webcrawler.com>
<http://www.cs.colorado.edu/home/mcbryan/www.html>
<http://www.aldea.com/bluepages/tool.html>
<http://www.adobe.com/prodindex/acrobat/readstep.html>
<http://www.ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html>

6. BEST PRACTICES USING THE WWW IN THE CLASSROOM

Use of the WWW During Instruction

| Level/Factor | Description | Source |
|---|--|--|
| Distance Learning | <ul style="list-style-type: none"> No physical classroom Student uses the WWW to access lesson instructions, for research, to complete activities and tests, and to submit work to instructor Communication and feedback from instructor through e-mail or other online resources | <ul style="list-style-type: none"> http://fre.www.ecn.purdue.edu/fre/asee/fie95/4c5/4c52/4c52.htm http://www.cac.psu.edu/~dlp/PS/psintro.html |
| The WWW as Sole Delivery Mechanism in Classroom | <ul style="list-style-type: none"> The WWW in classroom or lab setting Lesson instructions, activities, and content are all delivered through the WWW Groups may collaborate with others outside the classroom on activities over e-mail Groups work together to complete activity online (one computer to one student or one computer to many students) | |
| The WWW with Other offline Activities | <ul style="list-style-type: none"> Lesson introduction or instruction provided offline, students use the WWW primarily as a resource or for sharing results with others outside the classroom (one-to-one or one-to-many computers to students) Virtual field trips by means of video links to experts at zoos, museums, space centers, etc. | <ul style="list-style-type: none"> http://www.schoolnet.ca/grassroots http://teams.lacoe.edu/documentation/projects/science/what-if.html |
| The WWW as a Demonstration Tool | <ul style="list-style-type: none"> The WWW is used as a presentation tool in the classroom, may have a projection device or students huddle around computer for demonstration | |

Interactivity with the World Wide Web

| Level/Factor | Description | Source |
|------------------------------------|--|---|
| Access People | <ul style="list-style-type: none"> Communicate or collaborate with people outside the classroom through e-mail, listservs, and chat rooms (e.g., work on lesson together, ask experts questions, request feedback on activities, etc.) Partnering with experts to learn (e.g. creative writing across the WWW with feedback from authors) | <ul style="list-style-type: none"> http://www.4teachers.org/feature/nebraska-yaf |
| Access Information | <ul style="list-style-type: none"> Research content areas Find supporting graphics, sounds, etc. for lesson activities | |
| Access People and Information | <ul style="list-style-type: none"> Collaborate and communicate with experts or peers Ask questions, share data and information Collaborate on research, lessons, learning activities | <ul style="list-style-type: none"> http://www.4teachers.org/testimony/friesen |
| Create and Generate Data | <ul style="list-style-type: none"> Consolidate data into findings Gather and report data for studies (e.g., help gather weather data for world-wide weather forecasting projects) Create own tools for learning Provide project showcasing | <ul style="list-style-type: none"> http://www.minnetonka.k12.mn.us/groveland/insect.proj/describe.html http://njnie.dl.stevens-tech.edu/curriculum/bp/index.html http://www.4teachers.org/keynotes/weis |
| Manipulate and Share Existing Data | <ul style="list-style-type: none"> Take existing data from the WWW and manipulate it to support lesson objectives (e.g., use weather data and other information gathered from databases to create online newspapers; use wind tunnel data to design a dragster; or use science data to practice making mathematical graphs) Provide interactive or "live" project showcasing in Web site active database | <ul style="list-style-type: none"> http://www.kgs.colorado.edu/home1.html http://www.lerc.nasa.gov/Other_Groups/K-12/WindTunnel/Activities/Drgstr_cars_inwndtun.html http://www.lerc.nasa.gov/Other_Groups/K-12/WindTunnel/Activities/graph_stud_data.html |

Types of World Wide Web Sites

| Level/Factor | Description | Source |
|---------------|--|---|
| Informational | <ul style="list-style-type: none"> • Site provides reference information (content explanations, news/history, concept examples, images) that can be used to complete lessons • No planned active interaction with site other than searching and reading | <ul style="list-style-type: none"> • http://www2.ed.psu.edu/espse/staff/droberts/ep406.html • http://www.sgi.com/Fun/free/gallery.html • http://www.aero.hq.nasa.gov/oastthp/edu/educate.htm |
| Instructional | <ul style="list-style-type: none"> • Lesson plans or activity instructions • May provide models, examples of expected outcomes • May be for the teacher to plan lessons or for the student to get directions for activities | <ul style="list-style-type: none"> • http://athena.wednet.edu/curric/weather/graphing/index.html • http://www.swifty.com/apase/charlotte/energy.html |
| Learning | <ul style="list-style-type: none"> • Site designed to enhance learning, cognitive processing, interactive investigation, and manipulation of content (may include electronic journals, worksheets, cause and effect models) • May require students to create sites, manipulate and report associated information and data, collaborate with other students, provide or receive feedback on performance | <ul style="list-style-type: none"> • http://la.saic.com/NASA/parts.html • http://www.ed.psu.edu/~insys/insects/Insect_Net.html |

Origination of Sites

| Level/Factor | Description | Source |
|-------------------|--|---|
| Teacher Created | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites to provide instruction for students • Incorporates instructional links to existing sites, communication and collaboration components, concept models, examples, worksheets, etc. | <ul style="list-style-type: none"> • http://gideon.k12.mo.us/info/staff.htm |
| Student Created | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites to demonstrate understanding of lesson content | <ul style="list-style-type: none"> • http://www.ies.wisc.edu/research/ies126/daves.htm • http://www.wsn.org/indexheavy.html • http://gideon.k12.mo.us/info/student1.htm |
| Authority Created | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites by an authority or expert in the topic content • Content is generally considered to be accurate | <ul style="list-style-type: none"> • http://weathereye.kgan.com/expert/index.html • http://www.exploratorium.edu/index.html • http://www.aero.hq.nasa.gov/oastthp/edu/educate.htm |
| General Public | <ul style="list-style-type: none"> • Development of informational, instructional, or learning sites by general public • No verification of accuracy of site topic content | |

7. TEACHER TUTORIALS

Producer

| Level/Factor | Description | Source |
|---------------|--|--|
| High producer | <ul style="list-style-type: none"> • Creates content • Manages WWW pages • Writes code • Uses multiple media types <ul style="list-style-type: none"> – Courses – Conferences – Workshops – In-service – Seminars • Tends to use more interactive strategies • Requires less internal initiative | <ul style="list-style-type: none"> • Various conferences and workshops on WWW development • Dozens offered locally by Colleges and Universities • Dozens offered nationally by Conference planners like Ziff-Davis • Fewer offered locally by school districts |
| Low producer | <ul style="list-style-type: none"> • Creates single media types <ul style="list-style-type: none"> – Books – Articles – WWW pages – Discussion groups and lists • Creates passive, non-interactive pages • Requires more internal initiative | <ul style="list-style-type: none"> • http://www.etc.bc.ca/tdebhome/in-service.html (Resources for Internet Workshops) • http://www.schnet.edu.au/Docs/Home/Edu/edtoc.html • http://www.lerc.nasa.gov/Other-Groups/K-12/K-12_homepage.html (NASA's Lewis Research Center High Performance Computing and Communications K-12 Homepage) • http://sunsite.unc.edu/cisco/subjects/subjects.html • http://sunsite.unc.edu/cisco/tech.html • www.dfrc.nasa.gov/education/handbook/index.html (The Internet Handbook for Educators) • www.gsn.org/gsn/articles/index.html • wwwtools.cityu.edu.hk/tools.htm (WWW Tools by Example) |

Integrator

| Level/Factor | Description | Source |
|-----------------|---|--|
| High integrator | <ul style="list-style-type: none"> • Identifies resources • Uses e-mail • Facilitates communication • Moderates electronic discussion groups • Designs interactions • Uses multiple media types <ul style="list-style-type: none"> – Courses – Conferences – Workshops – In-service – Seminars • Creates interactive environments • Requires less internal initiative | <ul style="list-style-type: none"> • Internet CD available at http://www.classroom.net • Internet for Educators (book) • Great Teaching in a One Computer Classroom (book, Tom Snyder Productions) • Technology for Teachers (workshop by West Branch Technology Center) |
| Low integrator | <ul style="list-style-type: none"> • Uses single or few WWW resources <ul style="list-style-type: none"> – Books – Articles – WWW pages – Discussion groups and lists • Uses the Web as a demonstration site | <ul style="list-style-type: none"> • http://www.etc.bc.ca/tdebhome/cln.html • http://www.etc.bc.ca/tdebhome/integrating.html • http://www.4teachers.org/premier/ • http://scrtec.org/track/tracks/s00070.html (Using The Internet: Beginner's Guide to Using the Web in the Classroom) • http://www.abo.fi/vocweb/interen.htm • http://schoolnet2.carleton.ca/english/ext/aboriginal/lessons/index.html • http://teachers.net/manual/ • http://www.lerc.nasa.gov/Other_Groups/K12/Summer_Training/teacher_training.html • http://sunsite.unc.edu/cisco/schoolhouse.html • http://sunsite.unc.edu/cisco/lounge/index.html • http://polyglot.lss.wisc.edu/lss/lang/teach.html |

8. LEARNING THEORIES AND TEACHING PRACTICES

Behavioral Perspectives

| Level/Factor | Description | Source |
|---------------------------|--|--|
| Operant Conditioning | <ul style="list-style-type: none"> • Learning is measured in terms of observable behaviors, these behaviors can be changed with different kinds of reinforcement • Generally takes the form of drill-and-practice work-sheets and reward systems | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm |
| Applied Behavior Analysis | <ul style="list-style-type: none"> • Uses principles of operant conditioning • Generally used for classroom management | <ul style="list-style-type: none"> • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm |

Cognitive Perspectives

| Level/Factor | Description | Source |
|---------------------|--|--|
| Constructivism | <ul style="list-style-type: none"> • Based on the idea that learning is a process of individual “meaning-making” • Some types are: anchored instruction, situated learning, case-based learning, and problem solving | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm |
| Generative Learning | <ul style="list-style-type: none"> • Learning can be fostered by allowing students to generate their own inferences, analogies, organizational frameworks, etc. for material • Often takes the form of exploratory learning environments | <ul style="list-style-type: none"> • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm • Ames, C. and Archer, J. (1988). “Achievement goals in the classroom: Students’ learning strategies and motivational processes.” <i>Journal of Educational Psychology</i>, vol. 80(3), pp. 260–267. • Wittrock, M. C. (1974). Learning as a generative process. <i>Educational Psychologist</i>, vol. 11, pp. 87–95. |

Cognitive Perspectives (Continued)

| Level/Factor | Description | Source |
|-------------------------|---|--|
| Self-Regulated Learning | <ul style="list-style-type: none"> • An integration of ideas from metacognition, motivation, and learning behaviors, SRL strives to foster learners who are active agents in their learning process • Classroom approaches include strategy instruction and motivation-building | <ul style="list-style-type: none"> • Corno, L. (1986). "The metacognitive control components of self-regulated learning." <i>Contemporary Educational Psychology</i>, vol. 11, pp. 333–346. • Meece, (1994). In D. Schunk and B. Zimmerman (Eds.), <i>Self-regulation of Learning and Performance: Issues and Educational Applications</i>. Hillsdale, NJ: Lawrence Erlbaum Associates. • Miller, R. B. Behrens, J. T., Greene, B. A., and Newman, D. (1993). "Goals and perceived ability: Impact on student valuing, self-regulation, and persistence." <i>Contemporary Educational Psychology</i>, vol. 18, pp. 2–14. • Pintrich, P. R., and De Groot, E. (1990). "Motivational and self-regulated learning components of classroom academic performance." <i>Journal of Educational Psychology</i>, vol. 82, pp. 33–40. • Pintrich, P. R. and Garcia, T. (1994). In D. Schunk and B. Zimmerman (Eds.), <i>Self-regulation of Learning and Performance: Issues and Educational Applications</i>. Hillsdale, NJ: Lawrence Erlbaum Associates. • Pressley, M. and McCormick, C. B. (1995). "Strategies and metacognitive regulation of strategies: basic theory and research." In <i>Advanced Educational Psychology for Educators, Researchers, and Policymakers</i> (pp. 27–47). New York, NY: Harper Collins College Publishers. • Pressley, M., Snyder, B. L., and Cargillia-Bull, T. (1987). "How can good strategy use be taught to children? Evaluation of six alternative approaches." In (Ed.) <i>Transfer of Learning</i>. New York: Academic Press. • Ridley, D. S., Schutz, P. A., Glanz, R. S., and Weinstein, C. E. (1991). "Self-regulated learning: the interactive influence of metacognitive awareness and goal setting." <i>Journal of Experimental Education</i>, vol. 60(4), pp. 293–306. • Schunk, D. H. and Zimmerman, B. J. (Eds.), (1994). <i>Self-regulation of Learning and Performance: Issues and Educational Applications</i>. Hillsdale, NJ: Lawrence Erlbaum Associates. • Zimmerman, B. J. (1986). "Development of self-regulated academic learning: Which are the key subprocesses?" <i>Contemporary Educational Psychology</i>, vol. 11, pp. 307–313. • Zimmerman, B. J. (1989) "Models of self-regulated Learning and academic achievement." In B. J. Zimmerman and D. H. Schunk (Eds.), <i>Self-regulated Learning and Academic Achievement: Theory, Research, and Practice</i>. New York: Springer-Verlag. • Zimmerman, B. J. and Schunk, D. H. (Eds.), (1989), <i>Self-regulated Learning and Academic Achievement: Theory, Research, and Practice</i>. New York: Springer-Verlag. |

Cognitive Perspectives (Continued)

| Level/Factor | Description | Source |
|--------------------|---|--|
| Metacognition | <ul style="list-style-type: none"> • Metacognition means “knowing about knowing”, metacognitive strategies can be useful in the learning process • Typically takes the form of strategy instruction | <ul style="list-style-type: none"> • Brown, A. L. (1978). “Knowing when, where, and how to remember: A problem of metacognition.” In R. Glaser (Ed.) <i>Advances in Instructional Psychology</i>, (vol. 1, pp. 77–165). Lawrence Erlbaum Associates: Hillsdale, NJ. • Garner, and Alexander, (1989). “Metacognition: Answered and unanswered questions.” <i>Educational Psychologist</i>, vol. 24(2), pp. 143–158. • Pressley, M. and McCormick, C. B. (1995). “Strategies and metacognitive regulation of strategies: basic theory and research.” In <i>Advanced Educational Psychology for Educators, Researchers, and Policymakers</i> (pp. 27–47). New York, NY: Harper Collins College Publishers. • Pressley, M., Snyder, B. L., and Cargillia-Bull, T. (1987). “How can good strategy use be taught to children? Evaluation of six alternative approaches.” In (Ed.) <i>Transfer of Learning</i>. New York: Academic Press. |
| Concept Learning | <ul style="list-style-type: none"> • Examines how learners create understanding of new concepts, also how old concepts are revised or updated • Conceptual change is taught through the use of “refutational texts” | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html |
| Dual Coding Theory | <ul style="list-style-type: none"> • Describes information in long-term memory as verbal and nonverbal representation • Instructional implication is that materials should include both verbal and nonverbal components | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Sadoski and Paivio (1994). In R. B. Ruddell, M. R. Ruddel, and H. Singer (eds.). <i>Theoretical Models and Processes of Reading, 4th Edition</i>. Newark, DE: International Reading Association. |
| Schema Theory | <ul style="list-style-type: none"> • Describes the information in long-term memory in terms of a semantic network with related information grouped in schemata • Implication for instruction is that material needs to be organized in a way that can easily be incorporated into a person’s schemata | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Anderson, (1994). “Role of the reader’s schema in comprehension, learning, and memory.” In R. B. Ruddell, M. R. Ruddel, and H. Singer (eds.). <i>Theoretical Models and Processes of Reading, 4th Edition</i>. Newark, DE: International Reading Association. |
| Problem Solving | <ul style="list-style-type: none"> • Examines the problem-solving process, delineating between well-structured and ill-structured problems • Specific steps need to be taken when presenting well-structured or ill-structured problems | <ul style="list-style-type: none"> • Jonassen, D. H. (1997). “Instructional design models for well-structured and ill-structured problem-solving learning outcomes.” <i>Education Technology Research and Development Journal</i>, vol. 45(1), pp. 65–94. |
| Elaboration Theory | <ul style="list-style-type: none"> • Learning is a process of elaborating on existing knowledge • Instruction should be arranged in order of increasing complexity for optimal learning | <ul style="list-style-type: none"> • Reigeluth, C. M. (1987). “Lesson blueprints based on the elaboration theory of instruction.” In C. M. Reigeluth (ed.) <i>Instructional Theories in Action</i>. Hillsdale, NY: Lawrence Erlbaum. pp. 245–287. |
| Tetrahedral Model | <ul style="list-style-type: none"> • Describes the learning process in terms of four interrelated factors: the learner, the teacher, the task, and the environment • Each factor needs to be considered when developing instruction | <ul style="list-style-type: none"> • Bransford, J. (1979). <i>Human Cognition</i>. Belmont, CA: Wadsworth. |

Motivational Perspectives

| Level/Factor | Description | Source |
|-------------------------|---|--|
| Flow Theory | <ul style="list-style-type: none"> • Motivation is highest when a learner is at a certain level of challenge • The learning task needs to be just difficult enough to demand attention and eliminate boredom while being easy enough to prevent frustration | <ul style="list-style-type: none"> • Dweck, C. S. (1989). "Motivation." In A. Lesgold and R. Glaser (Eds.) <i>Foundations for a Psychology of Education</i>, pp. 87–136. Lawrence Erlbaum Associates: Hillsdale, NJ. |
| Attribution Theory | <ul style="list-style-type: none"> • Motivation is largely determined by the factors to which a student attributes success or failure (i.e. attributing success to effort) • Teachers can change students' attributions by emphasizing effort rather than ability | <ul style="list-style-type: none"> • Dweck, C. S. and Leggett, E. L. (1988). "A social-cognitive approach to motivation and personality." <i>Psychological Review</i>, vol. 95(2), pp. 256–273. |
| Achievement Goal Theory | <ul style="list-style-type: none"> • Motivation can be described in terms of students achievement goals, students with performance goals are motivated by extrinsic factors (grades, praise), students with mastery goals are intrinsically motivated by the material itself • Materials should be made to be intrinsically interesting to students | <ul style="list-style-type: none"> • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm • Ames, C. and Archer, J. (1988). "Achievement goals in the classroom: Students' learning strategies and motivational processes." <i>Journal of Educational Psychology</i>, vol. 80(3), pp. 260–267. • Dweck, C. S. and Leggett, E. L. (1988). "A social-cognitive approach to motivation and personality." <i>Psychological Review</i>, vol. 95(2), pp. 256–273. • Miller, R. B. Behrens, J. T., Greene, B. A., and Newman, D. (1993). "Goals and perceived ability: Impact on student valuing, self-regulation, and persistence." <i>Contemporary Educational Psychology</i>, vol. 18, pp. 2–14. |
| Expectancy-Value Theory | <ul style="list-style-type: none"> • Motivation is largely determined by 1) the extent to which a student expects to be successful on a task, and 2) the value the student places on the task • Teachers should create interesting materials and promote positive thinking in students | <ul style="list-style-type: none"> • Dweck, C. S. and Leggett, E. L. (1988). "A social-cognitive approach to motivation and personality." <i>Psychological Review</i>, vol. 95(2), pp. 256–273. • Pintrich, P. R., and De Groot, E. (1990). "Motivational and self-regulated learning components of classroom academic performance." <i>Journal of Educational Psychology</i>, vol. 82, pp. 33–40. • Pintrich, P. R. and Garcia, T. (1994). In D. Schunk and B. Zimmerman (Eds.), <i>Self-regulation of Learning and Performance: Issues and Educational Applications</i>. Hillsdale, NJ: Lawrence Erlbaum Associates. |

Sociocognitive Perspectives

| Level/Factor | Description | Source |
|----------------------|--|--|
| Social Development | <ul style="list-style-type: none"> • Learning takes place in the social context of our culture and can be fostered by interactions between a student and an adult teacher • A teacher provides a structure, related to student prior knowledge for the instruction, because the student understands the concept being presented but has not mastered the associated skill or knowledge | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Vygotsky, L. S. (1978). <i>Mind in Society</i>. Cambridge, MA: Harvard University Press. |
| Cooperative Learning | <ul style="list-style-type: none"> • Groups have a common goal and foster individual and group accountability to meet that goal • Learning can be fostered by promoting positive interdependence among small groups of learners | <ul style="list-style-type: none"> • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm |

Developmental Theories

| Level/Factor | Description | Source |
|--------------------|--|---|
| Stage Theories | <ul style="list-style-type: none"> • Learning occurs in childhood through progressive stages of development; mastery of one stage is necessary before a learner can move to the next stage • Teachers should consider a child's stage of development and help the child move to the next stage | <ul style="list-style-type: none"> • Learning Theories: Funderstanding; http://www.funderstanding.com/learn.htm |
| Non-Stage Theories | <ul style="list-style-type: none"> • Learning in childhood occurs by a process of gradual non-stage knowledge acquisition • A teacher needs to scaffold instruction around a student's "zone of proximal development" | <ul style="list-style-type: none"> • TIP: The Theories; http://www.gwu.edu/~tip/theories.html • Vygotsky, L. S. (1978) <i>Mind in Society</i>. Cambridge, MA: Harvard University Press. |

PROJECT TEAM BIOGRAPHIES

Principal Investigators:

Dr. Barbara Grabowski – The Pennsylvania State University, Associate Professor of Education

Barbara Grabowski has a B.S. in elementary education and an M.A. in education. She has taught approximately six years in both elementary and middle schools in Maryland and Pennsylvania. She also has a Ph.D from Pennsylvania State University, University Park, Pennsylvania, in the Instructional System Design Program. Upon graduation, she worked at the University of Maryland developing multimedia products for physicians, the military, and the nuclear power industry. Following this work, she turned her attention to academia and has been a faculty member at both Syracuse University, Syracuse, New York and the Pennsylvania State University. Her research interest is in the design of appropriate uses of multimedia in instruction and learning.

Dr. Marianne McCarthy – Analytical Services and Materials, Inc., Learning Technologies Project Manager, NASA Dryden Flight Research Center

Marianne McCarthy earned her B.A. in psychology from the University of California at Los Angeles (UCLA), an M.A. in special education from the University of Northern Colorado, Greeley, Colorado and her Ph.D in psychology from the California Graduate Institute, Los Angeles, California. She has taught students with disabilities in grades 7 through 12. She has also served as the director of special education programs at Woodview Calabasas Hospital and the director of education for the Erikson Center for Adolescent Advancement. She began working with NASA DFRC on a research project with her children called the Electronic Mainstream, and later was hired to develop and implement education programs at DFRC.

Project Design Assistant:

Tiffany A. Koszalka – The Pennsylvania State University

Tiffany Koszalka is a first year Ph.D. candidate in the Instructional Systems program at The Pennsylvania State University, University Park, Pennsylvania. She completed an M.S. in Instructional Technology (1985) and has spent the last 11 years working as an instructional designer and human performance technologist in the corporate environment. Tiffany's main focus in the last five of those years has been in the design of highly interactive computer-based multimedia instruction. Her academic aspirations are to balance her practical experience with a theoretical and research foundation. Tiffany's main interests are in the areas of instructional design principles and methodologies, assessing learner perspective, and the effective use of emerging technologies for instruction.

Project Technical Assistant:

Angel Hernandez - The Pennsylvania State University

Angel Hernandez graduated from Bloomsburg University, Bloomsburg, Pennsylvania with a B.A. in Psychology (1992) and a M.S. in instructional technology (1994). After graduating he became Senior Instructional Technologist for Unisys Corporation in Blue Bell, Pennsylvania. He now works as an instructional technologist in the Smeal College of Business Administration with the Center for Instructional Technology at the Pennsylvania State University. In this position his efforts are spent working with faculty and technology in their classrooms. His main interests involve faculty support and delivery and development of instruction.

Project Team:

The following Pennsylvania State University project team was from INSYS 597 Teacher Training and Tools for Web-based Science, Math, and Technology Instruction and Learning, an advanced graduate seminar.

Connie Garrett is a Ph.D. candidate in the Educational Psychology program at Pennsylvania State University. She recently passed her comprehensive exams and is currently beginning her dissertation research. Her primary interests are in the areas of learning theory, measurement, computer-based instruction, and instructional systems.

Leah Iwinski completed a B.S. in elementary education from the University of Pittsburgh in 1989. Next, she completed an M.S. in elementary education from the University of New Mexico in 1993 and has taught numerous grades in national and international public and private schools. She spent a year teaching ESL (English as a Second Language) in Taiwan and is currently working as an ESL Instructor for Adult Community Education classes. Her interest in higher education and emerging technology issues has led her to pursue postgraduate work in Educational Psychology and Instruction Systems at Pennsylvania State University.

Tom Iwinski is a graduate student studying distance education at Pennsylvania State University. His interest is in developing international instructional materials for delivery by means of telecommunications and the Internet. He has a B.S. in communications media from Indiana University of Pennsylvania and an M.S. in instructional technology from Bloomsburg University, Bloomsburg, Pennsylvania. He is a published author of "Multimedia Training", a text with CD-ROM from McGraw Hill and has produced several CD-ROM training titles for the U.S. Department of Energy and U.S. Department of Defense (DOE). He is currently working as a consultant to a DOE contractor.

Ellen Kendall graduated from University of Maryland, Maryland with a degree in secondary education. She taught social studies in Maryland public schools for three years, then returned to school full-time to pursue computer programming. She attended USDA Graduate School in Washington DC and received a certificate in computer programming. Upon graduation, Ellen joined the staff as a lab assistant and instructor. She was hired by Amtrak Corporate Headquarters in 1984 as computer-based training developer. She designed and delivered end-user training for various departments of the corporation, specializing in personal computer applications. Ellen moved to Altoona, Pennsylvania in 1988 and taught in a private proprietary school and post-secondary education at a local vocational-technical school. Currently, she is employed as an instructor at the Center for Advanced Technologies, a joint venture of the Altoona Area School District and the Greater Altoona Career and Technology Center. She is also pursuing a masters degree in Instructional Systems at Pennsylvania State.

Chih-Lung Lin is a doctoral candidate in instructional systems at Pennsylvania State University. He has a B.S. and M.S. degree in computer science. His research interests are Computer Aided Instruction development and the use of Web sites in teaching.

Jim Lloyd has been involved in higher education publishing for over 20 years. In addition, he has been working in training and educational aspects of the sales division of a major publisher. Recently, he has been contributing to the planning and development of online resources for the sales and editorial divisions. Jim is interested in web-based instruction and training. He hopes to focus further on anchored instruction and constructivist learning and especially on transfer strategies.

Natalie Tiracorda is a 6th grade teacher in Pennsylvania at Mount Nittany Middle School in the State College Area School District with 23 years teaching experience. As a generalist whose assignment is to teach math, language arts, social studies, and science, she tends to use the Internet as a resource to enhance her background, provide new ideas for lessons, and stimulate her thinking on a variety of topics that interest her and/or are curriculum related. Her school district has recently written its Internet Use Policy and, to date, Internet resources are used primarily by faculty.

Felipe Vazquez has an M.A. in teaching English as a Second Language. He has 11 years of teaching experience in the U.S. and abroad. He taught a teacher training program and an English for Specific Purposes program in the faculties of medicine, economics, radio broadcasting, journalism, pharmacology, and psychology at the University in the Republic of Panama. He also taught in two elementary schools and for an intensive English Language Institute (CoSPA). In Panama he used software developed by the American Language Academy. In the U.S. he used e-mail and the Internet to teach writing and vocabulary. Felipe has also taught in the Office of Skills Training program at the Asian American Civic Association in Chinatown, Boston, Massachusetts in the Intensive English Communication Program at Pennsylvania State University, University Park, Pennsylvania and in the Interlink Language Center at Valparaiso University in Valparaiso, Indiana.

Other NASA Contributors:

Dr. Marchelle Canright – Langley Research Center

Dr. Marchelle Diane Canright has been employed by the NASA Langley Research Center, Hampton, Virginia since 1987 as one of its Education Programs Specialists. She serves as the Center Precollege Officer and is responsible for providing the Nation's precollege-level teachers and students and teacher education colleges and universities with relevant programs and products concerning NASA activities, and the results of those activities. She is responsible for the management of the following major programs at the local, state, and national levels: Professional Education Conferences, Teacher Preparation and Enhancement Services, Instructional and Curriculum Support and Resource Development, and Student Programs. She also serves as an advisory and collaborator with the development of Educational Technology and Distance Learning Initiatives intended for the K-12 audiences. Dr. Canright is also a prior classroom teacher. She taught fifth and sixth grade in Newport News, Virginia and served on the Newport News School Board from July 1988 to October 1991. She received her Ph. D. from Pennsylvania State University in the field of instructional systems, with certification in distance learning. She has received several honors and awards for her educational contributions including Newport News Public Schools Teacher of the Year, Outstanding Young Women in America, Who's Who in American Education, U.S. Presidential Letter of Commendation, National Aerospace Educator Award and the NASA Exceptional Service Medal. In January 1995, she received medal honors at the International Film and TV Festival for the distance learning series Mission Earth-Bound, a teacher enhancement program on the problem-based learning approach.

Jeff S. Ehmen – George C. Marshall Space Flight Center

Jeff S. Ehmen is an Education Specialist at the NASA George C. Marshall Space Flight Center, Huntsville, Alabama. As a member of the Education Programs Office, Mr. Ehmen supports a number of the Center's teacher enhancement services for kindergarten through 12th grade educators. He also manages two agency-wide programs for NASA Headquarters: NASA Spacelink, a nationally recognized World Wide Web site for educators; and the NASA Mobile Teacher Resource Center, which travels the United States supporting teacher workshops with NASA educational materials and services.

Industry Contributor:

Rebecca Beaty – Science Applications International Corporation (SAIC)

As a Program Manager for Science Applications International Corporation (SAIC), Los Angeles, California, Ms. Beaty has been managing the development and installation of systems designed to foster the use of networks and telecomputing technologies in the K-12 educational environment in support of Advanced Research Projects Agency (ARPA) and NASA K-12 outreach programs, in addition to individual schools and districts. In doing so, she has worked extensively with individual schools, district "clusters," and districts to assist teachers and administrators in training and applying networking technologies for both instructional and administrative purposes. Specific capabilities facilitated by SAIC under these efforts were dedicated Internet access, extension of Local Area Networks, creation of Wide Area Networks, implementation of Internet security measures and facilitation of online curriculum development. In addition, Ms. Beaty has worked with commercial and Government customers to facilitate similar connectivity throughout their organizations. Ms. Beaty has an M.A. in Communications Management with an emphasis in Information Technology from the University of Southern California, Los Angeles, California.

Project Sponsor:

E. Lee Duke – NASA Dryden Flight Research Center, Chief of Public Affairs, Commercialization, and Education

Lee Duke graduated from the University of California at Berkeley with a B.S. in physics. He has worked at NASA DFRC in a variety of engineering areas on flight research projects for over 20 years. He took over the management of Education and Technology Commercialization about two years ago, and has been recently appointed Chief of a new organization, Public Affairs, Commercialization, and Education.

REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

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|--|---|--|--|--|
| 1. AGENCY USE ONLY (Leave blank) | | 2. REPORT DATE May 1998 | 3. REPORT TYPE AND DATES COVERED Technical Paper | |
| 4. TITLE AND SUBTITLE Web-Based Instruction and Learning: Analysis and Needs Assessment | | | 5. FUNDING NUMBERS WU 332-41-00-M1-00-TT-07 | |
| 6. AUTHOR(S) Barbara Grabowski, Marianne McCarthy, and Tiffany Koszalka | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Analytical Systems and Materials, Inc. Hampton, Virginia Pennsylvania State University University Park, Pennsylvania 16802-1303 | | | 8. PERFORMING ORGANIZATION REPORT NUMBER H-2235 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NASA Dryden Flight Research Center P.O. Box 273 Edwards, California 93523-0273 | | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/TP-1998-206547 | |
| 11. SUPPLEMENTARY NOTES Presented at INET 1998 Internet Summit, Technology and Learning Tract, Geneva, Switzerland, July 1998. Barbara Grabowski and Tiffany Koszalka, Pennsylvania State University, University Park, Pennsylvania, Grant NAG 4-113; Marianne McCarthy, Analytical Systems and Materials, Inc., Hampton, Virginia, Contract NAS 4-50066. E. L. Duke, NASA Technical Monitor. | | | | |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified—Unlimited Subject Category 81 | | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) An analysis and needs assessment was conducted to identify kindergarten through grade 14 (K-14) customer needs with regard to using the World Wide Web (WWW) for instruction and to identify obstacles K-14 teachers face in utilizing NASA Learning Technologies products in the classroom. The needs assessment was conducted as part of the Dryden Learning Technologies Project which is a collaboration between Dryden Flight Research Center (DFRC), Edwards, California and The Pennsylvania State University (PSU), University Park, Pennsylvania. The overall project is a multiyear effort to conduct research in the development of teacher training and tools for Web-based science, mathematics and technology instruction and learning. The project team conducting the research consisted of graduate students at PSU under the supervision of Dr. Barbara Grabowski, Associate Professor, PSU, and Dr. Marianne McCarthy, Learning Technologies Project Manager at DFRC. Jeff Ehmen of the Marshall Space Flight Center Spacelink program, Dr. Marchelle Canright of the Langley Research Center Office of Education and Lee Duke, Chief of Public Affairs, Commercialization, and Education at DFRC also contributed to the research effort. The areas investigated included administrative infrastructure, technology infrastructure, teacher factors, school curriculum, existing Web-based NASA materials, best practices using the WWW in the classroom, teacher tutorials and teaching and learning philosophy. | | | | |
| 14. SUBJECT TERMS Education, Learning technology, Pedagogy, Teacher tutorials, World wide web | | | 15. NUMBER OF PAGES 76 | |
| | | | 16. PRICE CODE A05 | |
| 17. SECURITY CLASSIFICATION OF REPORT Unclassified | 18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified | 19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified | 20. LIMITATION OF ABSTRACT Unlimited | |