Statewide Design

eLearning System for Arizona Teachers and Students

eSATS

Customer: Arizona K-12 Education

September 2005
Design Version 3

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Preface 1

Initial Design Team: The eSATS design team was formed under the auspices of Greater Arizona eLearning Association, an industry cluster within Governor's Strategic Partnership for Economic Development. The eSATS volunteers who developed Design Version One from mid 2003 to mid 2004 were:

Ted Christensen - Arizona Board of Regents
Eugene Holmquist - Ensynch
Ted Kraver – Global eLearning Industry Association
Glen Shand - Digital Concepts Inc. and Co-Chair Greater Arizona eLearning Association
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Kathy Young - Ariaratnam Solution Select Consulting and Co-Chair Greater Arizona eLearning Association
Jim Zaharis - Greater Phoenix Leadership

DESIGN GOALS
Academic Performance => Prepare Arizona's children to graduate from high school with a clear path to lifelong learning, the 21st century workplace, training for good citizenship, and family happiness.

Design Challenge => Transform Arizona's Statewide K-12 education from the current technology-enhanced legacy system to a true eLearning system.

Time/Cost Constraints => Limit the ten-year net cost/per/student to 3% of current K-12 Expenditures, with post-transformation costs lower than current costs.

2005 Legislative Effort: In 2004 eSATS was incorporated as a 501(c3) non-profit educational (design-advocacy) organization. The eSATS design was captured in Senate Bill 1181, which went to committee with bipartisan sponsorship. Although all thirty-two legislators understood and liked the concept after being briefed on the bill, liked the visionary - pragmatic approach of the eSATS eLearning design, the first year $135 million price tag kept it from being heard during Arizona's tight 2005 fiscal year.

2006 Legislative Preparation: Much has been learned from the past legislative session, and Design Version Three was completed by August 31, 2005 to includes current Arizona K-12 eLearning implementations by many sources. Policy and plans for eLearning being developed for our Governor, AZ Department of Education, educational associations and districts are reflected. A legislative team of advocates and support will be ready by October to write and support a new bill in the 2006 legislative session.

Notice: *Unless so noted, it is not to be presumed that any of the organizations or individuals referenced in this design document have approved or committed to participate in the creation or advocacy of the eSATS design.*

Prolog: Mental Model for K-12 eLearning

Challenge: When industries are transformed by technology, new descriptive terms become necessary. "Horse-less carriage" and "flying machine" become "automobile" and "airplane". "*Educational technology*" was good enough when legacy education processes of lecture, seat work and recitation were supplemented by computer labs. But during the past ten years, processes have started to shift toward guide-on-the-side integration of "*learning technology*" into the classroom. eSATS eight-year vision is of 1:1 computer-student access, continuous teacher professional development, digital curricula with formative assessment, and use of the Internet's resources -- the new term is "eLearning."

What is eLearning?: Small "e" and capital "Learning" expressed the team's belief that computers, digital media, digital curriculum and systems are in a supporting role to learning which takes place within the teacher-student nexus. No one will argue about the difficulty of creating a mental model of eLearning, let alone communicating that model to others. The learning industry, unlike other mature industries, is focused on the mind rather than on materiality.

Design Criteria: The eLearning design criteria must produce a system to deliver maximum and sustained academic achievement. The connection between student and teacher was selected to be center of the eSATS design:

> The student --with teacher, family and community-- develops an Individual Learning Plan (ILP) that is renewed for each of the 13 curriculum years within K-12 education;
>
> Then, students and teachers spend three to seven times more time in relating and communication with one another to execute that plan;
>
> Digital curriculum is fine-tuned tool to meet individual learning needs;
>
> The learning is delivered for each subject at a pace most effective for the student;
>
> Continuous formative assessment (minute-by-minute, hour-by-hour) guides the student and teacher collaboration process;
>
> The student can learn within a traditional class or small team, or as an individual learning; depending on the most effective learning group for the student and digital curriculum;
>
> The curriculum year ILP is complete when and only when the student masters the required curriculum as documented by summative assessment.

With these criteria for K-12 learning, the design is implemented with the support of continuous professional development, digital curriculum, computers, connectivity, statewide and local data system, and technical support.

Keep the Teacher-Student learning and "e" front and center as you review this System Design to evolve your mental model of eLearning.

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Executive Summary

What Needs to be Done:

The Mission of Arizona's Department of Education

"To increase the quality of public education in the State of Arizona by raising expectations and providing support, resources and assurances that enable schools and students to excel." [28]

How To Do It:

The Mission of eSATS

"To increase the academic performance and retention of students, and the professional performance of teachers within Arizona's K-12 education system to meet and exceed the raising expectations of the 21st Century knowledge economy using the extraordinary accessibility, efficiency, effectiveness and accountability of an eLearning systems design.

Goal

Deliver individualized mastery learning to all Arizona students, which will produce significant increases in academic achievement and graduation rates by 2012.

Guiding Belief and Logic

To achieve the goal requires a transformation, not just incremental reform of K-12 education. eLearning is the only cost effective means to effect this transformation. eLearning is the transformation of choice for 21st Century workforce training[21], higher education and military simulation. Arizona has unique eLearning strengths. By implementing eLearning transformation of K-12 education now with a system design Arizona would lead the nation in both education and economic development in ten years. Arizona's cluster of eLearning enterprises and eLearning K-12 education would become the center of the vortex of the global eLearning industry.

Strategy

Us a foundation of 15 years of research and experience to create a systems design and advocacy plan that is uses to write and pass legislation that enables and funds the K-12 eLearning transformation.

Key: Large Increase in Teacher-Student Contact Time

"eLearning System for Arizona Teachers and Students"(eSATS) was selected to emphasize the connection between student and teacher that is supported by digital curriculum. The goal is not to replace or disintermediation the teacher, but rather to allow much more teacher-student contact time for subject mastery. Though it seems counter-intuitive, eLearning will actually make education a more humanized process.

Legacy Education

Legacy education form of teacher-student interaction based on lecture, seat work and recitation has been developed to a high level of effectiveness over the past 125 years. But it is at the end of its innovation cycle with its current tools of books and blackboard.

Transformation Requires Different Approach than Reform

Legacy education reforms are made slowly at the margins by crafting imperatives, making plans and advocating for change. But effective transformation happens quickly and needs a powerful driver that can address the entire education system. That driver is a **systems design** that includes all aspects and players (education, business, governance, eLearning enterprises) in the transformation.

Design Summary

2005-2008 Three Year Bridge (Intellectual & Acceptance Infrastructure)

- Education and Professional Development Institute built to support;
  - $1200 per teacher per year professional development (mostly on-line);
  - Colleges of education transformed to eLearning;
- Notebooks and essential software suite for every teacher;
- One eLearning master mentor per 50 teachers;
- Digital Curriculum Institute built to provide:
  - eLearning extension agents for every classroom;
  - Access to universe of qualified digital curriculum selectable for student's individualized learning needs;
- Auditor General creates accounting-auditing system to fund individual students for "mastery year" rather than "seat year";
- High-speed connectivity to Internet into every Arizona classroom;
- 150-300 current schools funded and supported to transform to eLearning Centered Schools.

2008-2012 Five Year Build Out (Reaching All Teachers & Students)

- 20% teacher salary increase - eLearning certification + productivity;
- Computer interface to student 1:1 ratio in classroom
- Student and teacher to state level, a full access data-decision support system for administration, assessment (formative & summative), access to professional development and instruction, research;
- Technical support delivers 99% "up" time;
- Rest of 2000 traditional and Charter schools transformed to eLearning Centered Schools;

Challenge => Opportunity

Over the next ten years Arizona's population of 1,000,000 students and 50,000 teaching professionals is on pace to grow to 1,350,000 students and 65,000 teachers. Growth of this magnitude places huge stresses on our ability to build schools, engage highly qualified teachers and expand our supporting systems. But growth also provides a unique opportunity to adopt eLearning within new schools as well as transform existing schools. It also provides an opportunity to incorporate the long range cost savings afforded by eLearning.

Even though Arizona is a low cost K-12 education state, the total bill for the next 10 years including growth will be approximately $94 billion. This is based on an all-up current cost of $8400 per student and no inflation. The Rodel Foundation, in an exceptionally comprehensive 2004 study of legacy education, calculated the cost of investing in their "Lead with Five" reforms as $1900 per student which brings the ten -year cost of the best possible legacy education system for Arizona to $116 billion. The eSATS ten year net cost with

savings is $2.5 Billion with a total of $96 billion or a 2.2% increase for ten years. Net savings are promised after the tenth year.

The design team sought the strongest possible linkages with the players in education including the major associations, institutes, colleges and districts; in governance from the governor, boards, agencies, legislature and department of education; in business from leading companies and associations; and in eLearning enterprises. Where possible their emerging policies and initiatives were incorporated into the eSATS design.

Section 1 New Era => New Technology

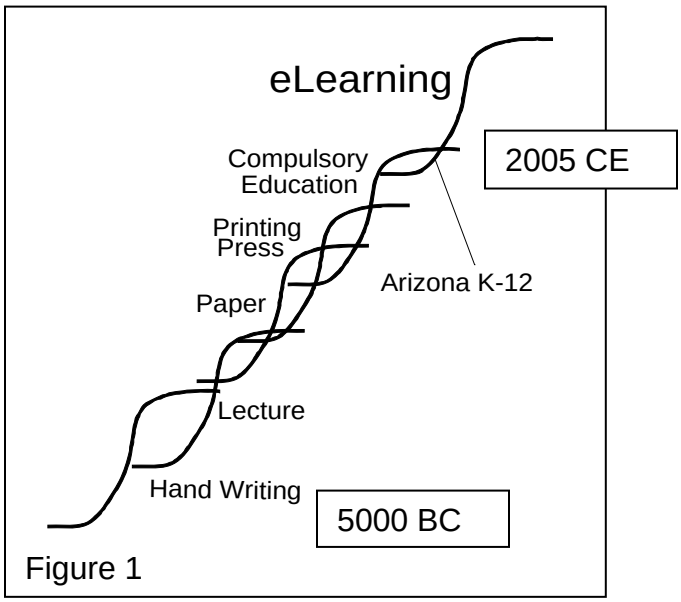


Figure 1

Learning Innovation Cycles

Reading, writing, and education have always been intertwined. When writing was invented seven thousand years ago, it immediately created illiteracy.[32] The ancient Middle Eastern desert dwellers could have called it the "analog divide." Forty-five hundred years later, a Roman sergeant shouted instructions to his troops, and the lecture was born. Paper was invented by Ts'ai Lun during 105 CE in China, and he profited handsomely. It took Europe another 1,000 years to re-invent papermaking. In 1450, Gutenberg invented the printing press, and the cost of books dropped by a factor of 400, and the analog divide closed somewhat. In the 1890s, our legacy K-12 education system with its components-- lecture, seat work, recitation and books-- was penned into law.

The current technological innovation, eLearning, is transforming learning once again. It changes the analog divide to digital and then closes the divide it so anyone can step across.

Demand Exceeds Marginal Improvement

Let's blame Alvin Toffler[3] for our current K-12 problems. The author of "Future Shock" named the global economic transformation: agricultural age begat industrial age begat information age. The waning of the agricultural age triggered compulsory education. During the recent industrial age our schools taught basic skills to most students and higher-level skills to those going into the professional ranks. With plenty of manual jobs, legacy education met the demand, and continuous marginal improvement adapted to evolving needs. Employers and the public were satisfied.

Then the information age upset the apple cart.

Since the 1950's, blue collar jobs have plunged from 50% of the available employment to well under 25%, to be replaced with white collar jobs, while the professional ranks have remained relatively constant at 25%.

While basic literacy skills are mandatory for both manual and white collar jobs, many technicians in the trades now need a higher level of literacy and thinking skills than office workers. The rapid growth of this new demand has exceeded legacy education's ability to deliver. Arizona leaders and public-private organizations have been working hard for decades to reform Arizona's K-12 system. Faced with a large and complex system under decentralized governance they have made only limited progress.

Continuous marginal improvement seems no longer effective. So what about addressing legacy education from a systems approach?

Transformation Needed

In 2004, Arizona's Rodel Foundation conducted a well funded comprehensive study using expert consultants in legacy K-12 reform. The consultants were charged with reviewing the research on all potential K-12 reforms that could improve academic performance. They developed "Lead with Five" recommendations of the most effect reforms and calculated the cost.[73]

Their data indicated that Arizona could move from 44th out of 50 states to **average** in academic performance if these reforms were adopted statewide. With expected 3% annual growth rate in Arizona school population over the next ten years the total cost of the current system at a fixed $8400 of public funding per student will be $94 billion. The "Lead with Five" improvements would cost an additional **$1900** per student, pushing the ten-year cost to approximately $116 billion.

AZ Student Population	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15
Increase	0.031	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Students	950000	978500	1007855	1038091	1069233	1101310	1134350	1168380	1203432	1239535	1276721
Funding-Millions	$8400	8219	8466	8720	8982	9251	9529	9814	10109	10412	10724
Cum Current		8219	16685	25405	34387	43638	53166	62981	73090	83502	94226
Plus Rodel	$1900	10079	10381	10692	11013	11343	11684	12034	12395	12767	13150
Cum Rodel		10079	20459	31152	42165	53508	65192	77227	89622	102389	115539

Annual and Cumulative Costs ($Millions) with Legacy K-12 Education

Reaching the average of current United States academic performance would be a great achievement. But it would fall far short of what is needed for an educated population competitive in the 21st Century economy.

Clearly the best that legacy K-12 education can offer is not enough and is not cost effective. Another alternative is needed. When an entrepreneur is boxed in by performance and/or cost barriers, he usually takes a serious look "outside the box." In the information age this invariably means looking at emerging technology. The step to solution is to determine what customer's key decision leader wants and will they buy.

Voice of the Customer

In the early 1990's the conventional wisdom said that K-12 education had a few more years in the political spotlight, and then other issues would crowd it out. Surprise! Twelve years later every governor, business leader and national spokesman remains committed to reform K-12 education.

- Governor Napolitano: “My first priority, today and always, is education. ... fresh look at re-engineering our public school system to suit the modern needs of our students, instead of retrofitting the same outdated model we have been struggling with for decades.”[74, 75]
- Supt. of Ed. Tom Horne: “Our planned state support for technology and data-driven instruction will generate a major leap forward for teachers in individualizing instruction.”[46]
- Greater Phoenix Business Coalition: “Strengthen P-20 education which is vital to workforce.” (brochure).
- Greater Phoenix Leadership “…build leadership and create school environments in which all students achieve at high levels.” [77]
- Alan Greenspan: “Lack of educational training poses the greatest threat to future American prosperity.” (Arizona Republic - 2004)John Adams: “Laws for the liberal education of the youth are so extremely wise and useful, that, to a humane and generous mind, no expense for this purpose would be thought extravagant.”(early 1800’s – not speaking specifically about Arizona!)
- Ron Paige, U.S. Secretary of Education “Education is the only business still debating the usefulness of technology.”[72]
- Susan Patrick, Director of Educational Technology, U.S. Department of Education, “Seventy-two percent for all first graders use a home computer.”[72]

For the past two decades, public-private workshops addressing almost any community-economic subject have decided that K-12 education as the critical issue. Arizona is ready to move beyond imperatives for change and plans to change. Governor Napolitano’s re-engineering implied a legacy redesign, the eSATS design team looked outside the box to an eLearning re-engineering eLearning systems design.

Faced with an immense challenge that both dollars and decades had yet to solve, the team decided at the beginning to work with certain imperatives:

Meet the current challenge of the No Child Left Behind Act which mandates that all students perform at or above the C level without grade inflation and all teachers are highly qualified;

Prior attempts focused on computers and connectivity alone have not produced expected results, so we must look at the other end of the spectrum -- the learning nexus of teacher and student;

All research since Socrates shows that individualize tutoring, with the intrinsic reward of learning to mastery can engage almost all potential students and eliminate failure;

Build on the current Arizona implementations of eLearning and incorporate all existing reforms involving technology into the design.

The design started with secondary research of over 100 recent studies and support documents that plan and assess eLearning in K-12 schools and other venues. The task team relied on these sources and prior implementation designs as well as

knowledge of the current state of Arizona's K-12 eLearning to create the eLearning systems design for eSATS.

The eSATS design has two first steps that focus on the teacher – student nexus. The first is the transformation of the teaching process from legacy education to eLearning. Second is the movement of the digital curriculum and the computers out of the lab and into the classroom. The technology rich classroom is a must. It proves full student access starting with at least 4:1 students per computer interface and within a couple of years expands to 1:1.[9] Laptops at 1:1 have the added advantage of expand learning time in the home and flexibility in the classroom.[61]

Class rooms then become work spaces like those we all are familiar with. We can no longer accept one machine for each eight students, anymore than we can implement a learn-by doing environment for teachers with a few five year old computers in the back of the room.

System Design

A number of major eLearning "design reports" were used. Team members have played roles in the formation of the first four. They include:

- Federal government's Advanced Distributed Learning System for both civilian and military transformation of legacy training and education to global eLearning;[4]
- CEO Forum study results in four School Technology and Readiness reports for K-12 achievement; [1]
- Arizona Department of Education's Arizona Education Technology Plan 2004[43]; currently under revision for implementation.
- "Toward a Golden Age In American Education," U.S. Department of Education, National Technology Plan, Susan Patrick, January 2005. http://www.nationaledtechplan.org/ [76]
- A recent solicitation for a similar eLearning system by Homeland Security Agencies[7].
- Seven meta-studies/analyses by Dexter Fletcher of Institute of Defense Analysis and Robert Foster of Office of Secretary of Defense. [32 to 38]
- Learning for the 21st Century – A Report and Mile Guide for 21st Century Skills[72].

During the past twenty years, eLearning adoptions have continued to lay the groundwork. Almost all districts have some eLearning adoption in place. Vail High School is opened in the fall of 2005 with 1:1 computing for students. Paradise Valley District has notebooks and projectors for all teachers. Snowflake District has an exemplary rural adoption and Wilson District has had 1:1 computing with full teacher professional development and digital curriculum since 1993. Arizona School Services through Educational Technology has recently expanded its role in teacher professional development.
The School Facilities Board's investment of $240 million in technology equipment projects has brought an 8:1 ratio of multimedia computers to students and 100 MB connectivity to all classrooms in Arizona. The funding also provides access to digital

curriculum, Internet, and email for a million teachers and students through the Application Service Provider system of the Cox Education Network.

But state funding for this system ended June 30, 2005. This implementation, focused on computers and connectivity, had delivered about fifteen percent of what is needed for a complete and effective eLearning system. Arizona led nationally in this area of connectivity and portal support during the early 2000's and eSATS will build on this foundation.

K-12 eLearning objectives

Technology Tool Skills: The first is foundational, and is addressed by the Arizona K-12 Academic Technology Standards[78]. This standard focuses on technology tools to succeed in society, the workplace and education. eSATS assumes that these skills will be more than achieved when student learning is supported by the home computer and the other three components delivered by eSATS. The second component is using technology to learn basic skills. The third is learning higher skills with (information) technology[33]. A recent national study has defined the 21st Century Skills that include elements of all three, especially higher level thinking.

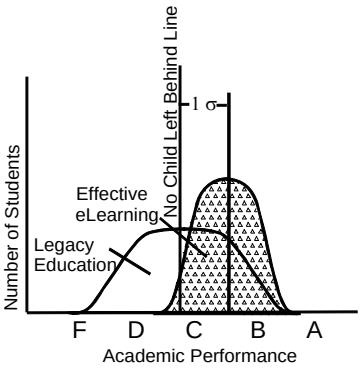
Basic Skills: reading, writing, speaking, memorization, and arithmetic. These are directly supported by computer applications which can include Computer Based Instruction (CBI) for drill and practice with immediate assessment feedback.

Higher Level Thinking: problem-solving ability, capacity to locate, evaluate, and use information via the Internet, multiple languages, effective multimedia use, conceptual development, critical thinking, creativity, and research skills are supported by productivity applications dealing with word processing, spreadsheets, databases, presentations; multimedia applications to deal with photographs, music composition/performance, movie making/editing, and CD, DVD, and web page construction tools; and tools supporting intelligent tutors, simulation, and synthetic environments.

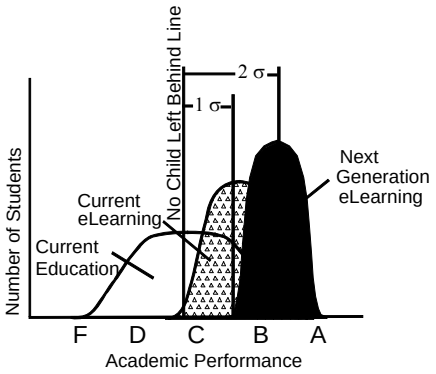
21st Century Skills[72]: Information and media literacy; communication; critical thinking and systems thinking; problem identification, formulation and solution; creativity and intellectual curiosity; interpersonal and collaborative; self-direction; accountability and adaptability; and social responsibility.

Research Goal for Academic Performance

eSATS must provide a student learning environment through which the Secretary of Defense's learning performance goal of one letter grade improvement can be achieved in each Arizona course.



Current eLearning Potential Fig 2



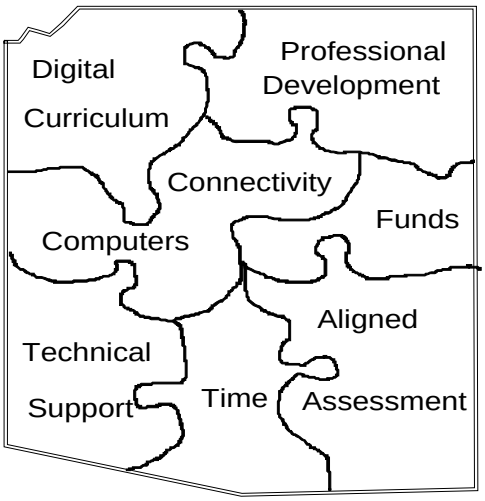
Next Generation eLearning Potential Fig 3

The holy grail of learning is one-on-one human tutoring. With tutoring, “C” students can consistently learn at the rate of “A” students as shown in the graph. Studies also show the bell-shaped performance curve narrows as it moves to the right. This will greatly reduce the “D” and “F” student dropouts due to academic failure. Individualizing the pace and engagement with eLearning also retains gifted students.

The ten-year eLearning research roadmaps produced by the federal government, national associations and Department of Defense describe the research to reach this level of improvement.[12] It is expected that over the next ten years this emerging eLearning technology will reach K-12 eLearning environments.

Arizona can move forward with effective eLearning now: Students entering Kindergarten are digital media savvy and ready for eLearning.[69] Arizona adults must only commit to adoption of a complete eLearning system. If any component of the system is weak, the rest will falter.

There are seven major components of the eSATS systems design:

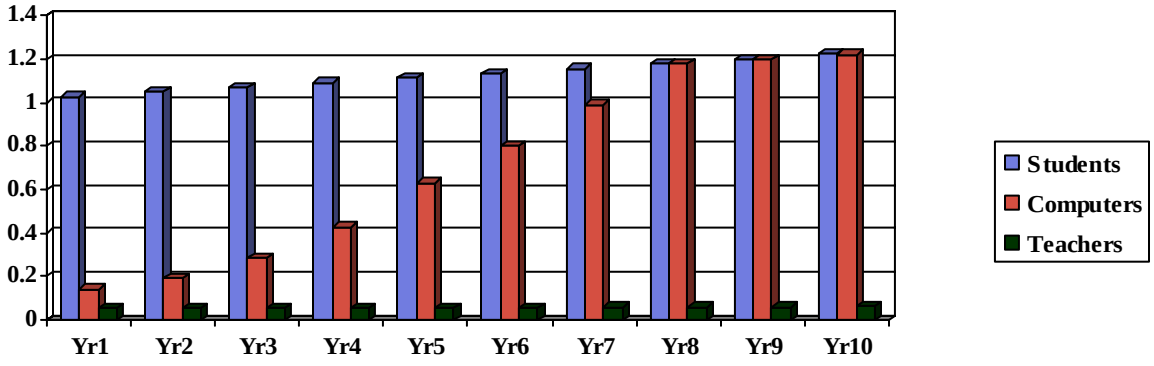


Seven eSATS Components Figure 4

- Education and professional development of teaching staff;
- K-12 subject and student appropriate digital curriculum with content and courseware;
- Digital assessments aligned to standards and student needs;
- Computer interfaces and high-speed connective fully accessible;
- Technical support;
- Time
- Funding

Forecasts and Assumptions \

- eLearning raises academic performance 30% to 50% moving Arizona's ranking from fourth quartile to the first quartile;
- The dropout rate will decrease significantly and the resulting increase in student population must be addressed in the financial calculations;
- Current growth will continue at a 3% compounded rate (30,000 new students, 1600 new teachers and many dozens of new schools each year);
- Four years will be needed for individual teachers to fully master eLearning theory and processes through professional development and education;
- It will require eight years to change from 8:1 to 1:1 students to computer ratio;
- Over 1000 new mentor teachers and 3000 technicians will be required;
- The current Student Accountability Information System-IDEAL system can be significantly expanded to fully serve the summative-formative assessment, administration, research and instructional needs of eSATS;
- An inclusive systems approach led by stewards is better than either a top-down or individual district by district approach;
- Adequate knowledge of and access to the global of sources of teacher education and professional development, and digital curriculum are not currently available;
- New formulas and regulations are needed to align funding with student-mastery year and abandon seat year funding;
- The most effective tranformational unit is the school;
- Arizona's current broadband initiative will complete the build out to all Arizona classrooms within three years;
- The major cost savings afforded by eLearning will applied to ameliorating the cost of implementing eLearning;
- The removal of one calendar year from the average Arizona student's K-12 education will be beneficially accepted by families, schools and our colleges;
- A three year bridging to build intellectual infrastructure will be needed before the five year buildup to full implementation can take place;
- Implementation funding will ramp up over four years and then decrease as cost savings start taking effect;
- The timing is right and leadership is ready, willing and able for the difficult task of implementing K-12 eLearning transformation in eight years.



Projections - Millions Figure 5

Section 2 Design Methodology, Experience and Advocacy

Design Methodology

There are two crucial knowledge sets needed before any large system design process can start. First are the needs of the customers: the educators and administrators who will have to implement the K-12 eLearning design, and the business people who need a 21st Century workforce and already use eLearning. The second is the design components, which come from the research communities (colleges, institutes, laboratories), professional development providers, and eLearning enterprises.

Although there major and minor redesign processes that will be continuous through implementation, the basic design sequence then matches performance requirements with expected performance of the component based system. A gap analysis determines what exists vs. what needs to be developed or acquired from available sources. Then the timing, costs, implementation phases, responsibilities, and assessment data aspects are developed. Finally it's back to the customer for approval, commitment and advocacy.

Voice of the Customer

Over past decades, eSATS design team members have been directly engaged with a wide range of customer-based participative strategic planning and pilot implementation processes. The idea that linked Arizona economy development and education technology was first articulated fifteen years ago within the Enterprise Network Strategic Planning Taskforce and was elaborated in the Phoenix Futures Forum (PFF) and Arizona Strategic Plan for Economic Development (ASPED). Up through the mid 1990s, the Learning/Research/Enterprise Inc. (PFF action group) and the Arizona Telecommunications and Information Council (ASPED foundation group) developed plans and laid critical groundwork for eLearning implementation.

Arizona Department of Education: In the early 1990s, Kathryn Kilroy of the Arizona Department of Education produced the first statewide K-12 technology plan: "Technology Integrated Educational Delivery System[45]." (TIEDS). Revisions in 1997[44] and 2002[6] were followed by 2004[43] "Arizona Educational Technology Plan". Arizona Educational Technology Plan used the results of a major workshop supported by leading Arizona businesses and facilitated by CRESMET of the ASU College of Engineering[16, 42]. A new Arizona Department of Education technology plan for 2005[81] is being developed by Cathy Poplin with the additional criterion that it be an implementation plan.

Arizona Learning Technology Partnership: In 1995, the L/R/E and ATIC, with AT&T support and Arizona Department of Education guidance, formed the Arizona K-12 Learning Technology Partnership (ALTP—a GSPED partnership). The ALTP www.altp.org created a statewide Arizona K-12 eLearning strategic plan with eight major efforts.

- Conducted focus groups with nine organizations that ranged from the Arizona Education Association to the Gila River Indian Community Schools. Soon afterward one of the groups, the K-12 technology directors, organized the Arizona Technology in Education Alliance (AZTEA) [48];

- Solicited and received eighteen white papers on requested topics for eLearning in Arizona K-12 education from expert leaders within what are now the eSATS four communities[47];

  Summary of White Papers

  A K-12 Superintendent's Perspective

  Apache-Navajo Counties: Rural Information Network Perspective

  Arizona Libraries Technology Issues

  Arizona Department of Education: Automation Plan

  Arizona Telecommunications and Workforce Development Issues

  Community College Link to the Arizona Learning System

  Economic Development Issues

  Education Software Market

  Effective Integration of Technology into School Districts

  K-12 Technology Directors' Perspective

  Legislative Issues

  Military Labs' Perspective on K-12 Learning Technology

  Parent Perspective

  Small High Technology Business View

  Teacher Training

  Teachers' Role in Educational Technology

  Telecommunications Providers' Issues

  University Support and Vision for K-12 Education

- Engaged a consultant to conduct thirty interviews with a different set of statewide leaders and experts in K-12 education[49];
- Produced a forecast of emerging technologies[50];
- Produced a study report in the eLearning situation in Arizona and other states[51].
- Facilitated a statewide (Phoenix, Tucson, Flagstaff and Sierra Vista) strategic planning task group using participative techniques and data from the prior studies to craft a statewide strategic plan for accelerated adoption of eLearning within Arizona's k-12 education system[54].
- Produced a visions-systems and issues study paper[52, 53].
- Developed a situation assessment on Arizona eLearning.[55]

In 1997 ALTP advocated at the legislature for accelerated adoption of eLearning, with the equipment and technology piece as part of the Students First legislation ,and the School Facilities Board guidelines to bring Arizona K-12 schools up to a minimum eLearning standard. The advocacy paid off with the School Facilities Board's $210 million build out by Qwest and Cisco of the 8:1 computers and high-speed connectivity into every K-12 classroom. The Cox Education Network received $27 million to provide an Application Service Provider, email addresses, and access to digital curriculum for Arizona teachers and students.

In 2000, eSATS team members were engaged in the Governor's Arizona Partnership for the New Economy (APNE) planning process. Their venue was the eLearning Hot Team, which advocated an eLearning industry cluster organization. From that came the Greater Arizona eLearning Association which became a cluster organization within Governor's Strategic Partnership for Economic Development until the dissolution of GSPED in December of 2003.

In early 2003, Greater Arizona eLearning Association interviewed leadership of over twenty leading Arizona eLearning enterprises. The second ranked issue (behind eLearning product research) was the need to use eLearning to transform K-12 education I Arizona. Most of these enterprises were not in the K-12 marketplace but felt the civic drive to use their eLearning knowledge to support K-12 education transformation.

The Greater Arizona eLearning Association board started with the 1997 ALTP "eLearning" strategic plan for K-12, reviewed the implementation of the Qwest-Cisco-Cox system, and decided to launch an eLearning design effort on September 1, 2003. The volunteer design team evolved a brisk set of tasks to be completed by the end of 2003:

- Identify and complete a set of interviews with Arizona business, governance and education steward-stakeholders for K-12 education (done);
- Create a first draft system design for full implementation of eLearning-based transformation of K-12 education – eSATS (done);
- Develop a crystal clear message (done);
- Organize an advocacy coalition of steward-stakeholders (done).

eSATS Team

eSATS design team members were experienced in Arizona educational advocacy. One of the team was part of the Special Education movement in the 1970s and early 1980s, which created funded programs for the special needs of 12,000 Arizona gifted and talented children. He was also president of one of the first twenty five charter schools in 1995 – for adjudicated youth. Several participated in the advocacy that resulted in the Qwest-Cisco-Cox system. Another was superintendent of Arizona's largest school district for fifteen years of eLearning adoption. The driver behind the Arizona Regents (Online) University was on the team, as well as the developer of the Application Service Provider for the Cox Education System were members. Included also was a founder of AzTEA, the information technology director of Peoria district, an early adopter of a major K-12 eLearning system.

Implementation Power Needed

Since the 1983 national study "A Nation in Crisis," many initiatives have been launched but few have had even marginal success. Now President Bush's "No Child Left Behind" initiative requires improvements that only eSATS is designed to achieve. eSATS goal for K-12 students to perform at one grade level higher is both audacious and practical enough to secure the attention of Arizona leadership. eSATS is poised to deliver on twenty years of expectations but attention is not enough, what is needed is commitment across the board. The produced the final criteria for eSATS – created the advocacy design in conjunction with the implementation design.

Enter P-20 Architecture and Stewards

To transform an entire state education system, an inter-organizational architecture is needed. Fortunately the P-20 architecture and its steward concept is accepted in Arizona. P-20 was developed by the Greater Phoenix Leadership and Maricopa Community College District and addresses the integration of education over the life span of Arizona's citizens. The four major sectors are ages 0–5 (Pre-K); Kindergarten to 12th grade (K-12); colleges—both community and universities; and employers—workforce. Governor Napolitano has created a P-20 council to address the high school – college transition for students. Support for eSATS must pass though all P-20 linkage points.

Stewards are defined in the Morrison Institute for Public Policy *Five Shoes Waiting to Drop on Arizona's Future*[82] as careful and responsible managers of what is entrusted to their care -- the counterpoint to one issue ideologues. Stewards work within an integrated vision, with broad collaborative networks in order to solve big complex problems. They commit to the long-term well being of places and people. They are leaders who cross boundaries and build coalitions for sustained action. Stewards are people who have 360-degree vision, recognizing interdependency between education, economy, environment, and social equity.

© Greater Phoenix Leadership Figure 6

The current education system has evolved historically as separate silos. But with new organizations like Arizona Business and Education Coalition[83] and Governors Council on Innovation and Technology,[84] effective linkages are being forged. First -generation eLearning is being adopted along the entire spectrum of P-20, easing implementation of eSATS. Supporting linkages will include colleges and enterprises providing teachers eLearning education and professional development. Preschools will provide students ready for K-12 eLearning. Military, federal and eLearning enterprise research on workforce eLearning will support the development of K-12 and teacher professional development curriculum. Government, business and education leaders have an image of workforce eLearning within their organizations. With eSATS the P-20 system will have a power center for their eLearning adoptions.

eSATS Advocacy Organizational Design

The organization that advocates implementation of the eSATS system design include comprise stewards seasoned with flame throwers. Although the organization may evolve into a larger coalition after its initial success, it must be entrepreneurial and flexible as a "gazelle". To position itself to attract steward-stakeholders, eSATS has connected-the-dots between current initiatives and built them into the eSATS desing.

eSATS design team has identified almost all entities engaged with eLearning to implement K-12 reforms. eSATS will attempt to include their linkage people as part of the eSATS advocacy coalition. As eSATS outgrows its flame throwers and builds a coalition, K-12 eLearning stewards would take ownership of the eSATS implementation initiative. Five K-12 steward groupings have been identified:

- K-12 Education—have the nitty-gritty task to embrace eSATS, implement it, and make it work;
- Higher Education—must educate the eLearning savvy teachers and research and develop new generations of digital curriculum;
- Businesses and Economic Development—They have the task to support the initial launch of eSATS and empower its advocacy;
- Government Entities—have the task to provide governance, advocacy, change rules and regulations and legislate the funding for the implementation of eSATS.
- eLearning Enterprises—have the task to provide eLearning expertise and entrepreneurial leadership to its launch and early growth, and deliver digital curriculum and educator professional development.

Section 3 System Design:
Innovation Central and Six Major Components

The eSATS system design draws on many sources but particularly the results of a five-year project (1996 to 2001) by the CEO Forum on Education and Technology[1] www.ceoforum.org, ceoforum@itstrategies.com. During that period, the forum published four major studies.[1] The nineteen forum members, high-level executives from an eclectic mix of major technology companies, consultant organizations, and national educational associations, were supported by Washington-based IT Strategies, headed by Ken Kay. Ken has a second home in Tucson and is involved with Tucson information technology associations.

The CEO Forum started the design process by integrating the four pillars (components) presented in President Clinton's Technology Literacy Challenge: Hardware, Connectivity, Digital Content, and Professional Development. Its summary product is the School Technology and Readiness (StaR) chart (Appendix A.) STaR charts are comprehensive matrix tools to assess progress of schools from Early Tech, Developing Tech, Advanced Tech, to Target Tech. The first report "Integrating the Four Pillars," was followed by "Digital Content" and "Professional Development." The final work addressed Student Achievement by integrating prior work with Assessment, Alignment, Accountability, Access, and Analysis.

State level design information and imperatives were drawn from Arizona Department of Education's "Arizona Education Technology Plan[6]" and "Masterplan for IT in Education (Singapore)[14]" among others. The current state of eLearning adoption in Arizona is between Developing Tech and Advanced Tech on the CEO Forum's progress chart. From that framework, the design team concluded that Arizona is about 15% of the way toward a full K-12 eLearning implementation. This level of adoption provides a strong foundation of people, systems, organizations and expertise to implemented complete system design.

Components: System designs are build from major interacting components. From the above sources and design processes eSATS was designed with six major components. Several require a new institute and new information system and financial system are required.

- **Teacher and Staff Education and Professional Development (institute);**
- **Digital Curriculum (institute);**
- **Assessment, Access, Accountability and Decision Support(information system);**
- **Computers and Connectivity;**
- **Technical Support;**
- **eLearning Center School (financial system).**

All systems need a leadership and control center. The "seven component" will be:"

- **Innovation Central (Institute)**

Most K-12 systems that have adopted educational technology have failed to reach their expectations for academic performance increase. Almost all have adopted an incomplete set of these seven crucial systems design components. Imagine a find jet airplane with automobile engines and no wheels. Past adoptions have struggled with the lack of funds for a complete system; early stage technology, resources and pedagogy; and sporadic upgrades.

The eSATS design team learned from these prior efforts and have strived to cover all bases. Innovation Central detailed design is followed by the other six components.

Note: The representation of this design in legislation is presented in Appendix B by arranging the sections of 2005 Arizona State Senate Bill SB 1181 into the framework of this Section 5.

Note: The use of the word “district” means school districts, and charter and alternative schools.

Section 3.1 eSATS Innovation Central (eSATS IC)

Large system innovation and transformations of the magnitude of eSATS can start with an ad hoc coalition of mutual interest. But once enabling and funding legislation is in place, the advocacy stewards and educational leaders require a single entity to coordinate and lead the statewide implementation. That independent organization will be eSATS IC.

eSATS IC, an Arizona non-profit corporation, should be housed within the community of educational organizations and State agencies, boards and departments centered in downtown Phoenix. It will be governed for the first ten years by a board of directors that have strong linkage to organizations within the five major communities (K-12 education, higher education, governance, business and eLearning enterprise). As the innovation-high growth phase winds down in five to ten years, eSATS IC will be dissolved. Or it may be redesigned to provide continuous transformational support and leadership.

With responsibility for a transformational program reaching $500 million a year level, the eSATS IC will grow to approximately fifty people during the first six years, and then shrink as eSATS matures. The fully burdened cost estimate is $100,000 per person.

eSATS IC will provide additional administrative funds to organization responsible for implementing major aspects of eSATS.

Arizona Department of Education has statewide responsibility for contracting with and funding the transformation of eLearning Centered Schools; in-service teacher and staff professional development; collaboration with Arizona Board of Regents for the eLearning Education and Professional Development Institute; Student Accounting and Information System (Student Accountability Information System) and all its expansions and extensions into the data and assessment areas; teacher notebooks and essential software and projectors; and instructional systems for eLearning and communication. Administrative costs would start at $4.5 million and plateau at $10 million in year six.

Arizona Board of Regents has the responsibilities to assure that the colleges of education graduate and support eLearning savvy teachers (both pre-service and graduate), house and support the Digital Curriculum Institute, step up eLearning research, house and support a K-12 ADL Co-Lab; and provide support and collaboration with Arizona Department of Education for the eLearning Education and Professional Development Institute. Administrative costs would peak at $4 million in year three and then decline to a $1 million in the out years.

Office of the Auditor General has the responsibility of designing, developing rules, prorogating and operating the eLearning Centered School accounting and auditing system. In year three administrative and legal-staff costs would peak at $2 million followed by a decline to $200,000 in the out years for education and training of district administrative staff.

Government Information and Telecommunications Agency has the responsibility for assuring that affordable high speed Internet is available to schools not yet served. Their administrative cost would be $300,000 for the first three years followed by a decline to $100,000 for ongoing efforts.

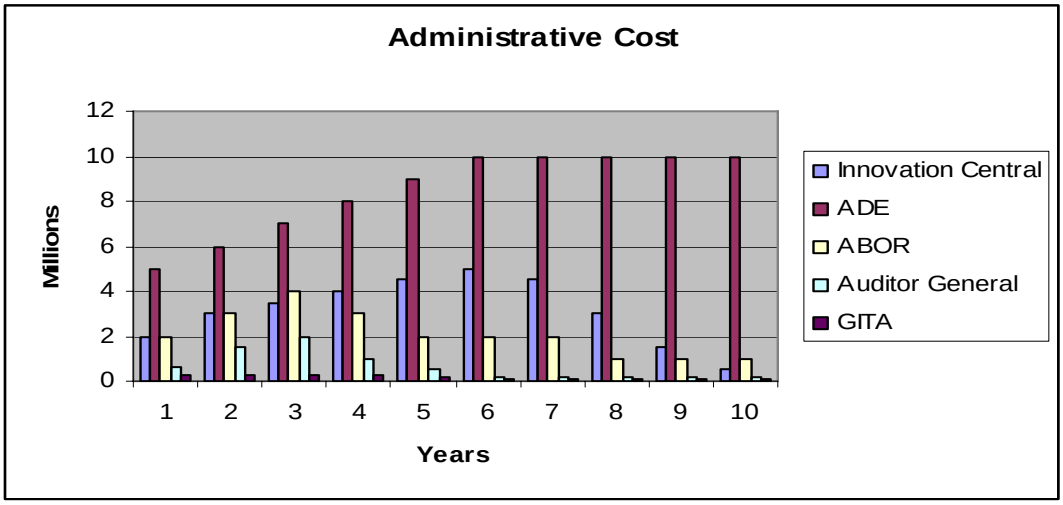


Figure 7

ADMINISTRATION											
Innovation Central		2	3	3.5	4	4.5	5	4.5	3	1.5	0.5
ADE		5	6	7	8	9	10	10	10	10	10
ABOR		2	3	4	3	2	2	2	1	1	1
Auditor General		0.6	1.5	2	1	0.5	0.2	0.2	0.2	0.2	0.2
GITA		0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Total State		**$12**	**$17**	**$20**	**$19**	**$19**	**$20**	**$20**	**$17**	**$16**	**$15**
$/Student		$12	$17	$19	$18	$17	$18	$17	$14	$13	$12

Table 1

Human Ecosystem

"The most pragmatic tool a business manager can have is a good theory." Peter Drucker

eSATS IC will take the initiative in developing research knowledge into operational policy and tools for eSATS implementation.

The heart of the information age is people working and learning together. It is a human based networked system that is quite different than the input-output of the industrial age factory model. Organizational and management theories are evolving but eSATS IC could gain a major competitive advantage if it had first use of organizational development theories for K-12 eLearning human systems. A leading body of theory results from the study of the human ecology system (ecosystem).

The June 2004 Arizona Town Hall participants along with a host of others have voiced the imperative "Parents must be partners with the school in the education of their children.[86]" The design team could not find a plan, let alone a proven design on how to deliver consistent parent support for every K-12 student. Especially with the economic, interests, knowledge level, language and time challenges of parents. eSATS must craft its own

solution within the context of eLearning and information age, the human ecosystem theory will be called on to provide the design tools.

Definition: Parents and schools are only part of the ecosystem that shapes and drives a student. Current theory describes this ecosystem with five layers:

- **Microsystem—**the student's family, home, school, peer group, church, immediate neighborhood…are all microsystems;
- **Mesosystem –** is two or more microsystems linked together. The interaction between home and school will reinforce behaviors within both systems;
- **Exosystem—** delivers indirect but powerfull effects as outside forces. These include board of education, parents work conditions, state academic standards, department of education, employer needs…;
- **Macrosystem--**includes cultural beliefs, values, attitudes, customs, national government, laws – propagated by the cultural memes and structure of society;
- **Chronosystem --** the student is influenced by different systems at different times over the years.

Resources: An opportunity is at hand in Arizona in the person of Greg Hickman. Greg was a researcher on the field of human ecosystem and at the Center for Arizona Future (Latti Coor) when he provided input to the eSATS design. He is now heading up a research program for the Rodel Foundation at the Arizona State University College of Business.

Dr. Hickman conceptualized a center that would develop K-12 human ecosystem policy and tools specifically for eSATS IC. This policy design would guide the implementation of eSATS along its twenty year growth cycle. The policy would guide the organizational and implementation redesign, launch, bridging from legacy education to eLearning, rapid growth and maturity. For example eSATS IC would use mesosystem and exosystem theory to guide eSATS interactions and expectations from its five communities. Microsystem and mesosystem theory would support significant enhancement of student-home-school interactions.

Human Ecosystem Center would be created for research and development on the human ecological aspects of Arizona K-12 education. The Human Ecosystem Center will be use all levels of the Arizona K-12 education system as its test subject. This systems approach will address all five layers of the ecosystem. Parents, students and teachers are expected to be the most critical aspects. But microsystem peer groups to exosystem state level leadership have critical roles to play. The results of this theoretical - field testing work would support development of policy tools and implementation designs to be used by eSATS IC.

The eSATS IC Human Ecosystem Center would not be a policy research center where the outcomes are papers, presentations and prestige. This would be a policy design and development operation focused on transforming Arizona K-12 education to an eLearning powerhouse. The data system from Student Accountability Information System in the AZ Department of Education will be expanded to include human ecosystem data at the appropriate level of granularity to support continuous eSATS policy redesign along its Chronosystem .

Human Ecosystem Center Design: This center will be created as a fully integrated policy development center. A center president and leading experts from the five major human ecosystem disciplines: microsystem, mesosystem, exosystem, macrosystem and chronosystem will be grouped in one location. There will also be at least three marketing-outreach-communications professionals to promote, develop and maintain two way connectivity and support between the center, its field customer-subjects and clients which are eSATS institutes and eSATS IC operations and leadership.

eSATS IC will contract with a currently operating or a newly formed organization to house, support and manage the Human Ecosystem Center. The Human Ecosystem Center will be operational within one year and fully staffed within two years. Guided and overseen by eSATS IC. The approximately 15 professionals will be joined with support staff who will provide outreach, education, field research and administrative functions.

Cost: The average cost with burden of an R&D professional of the caliber needed is $150,000 a year or $2.25 million for fifteen professionals. An additional $ $750,000 is needed for support staff, field study costs, consultants, facilities and outreach.

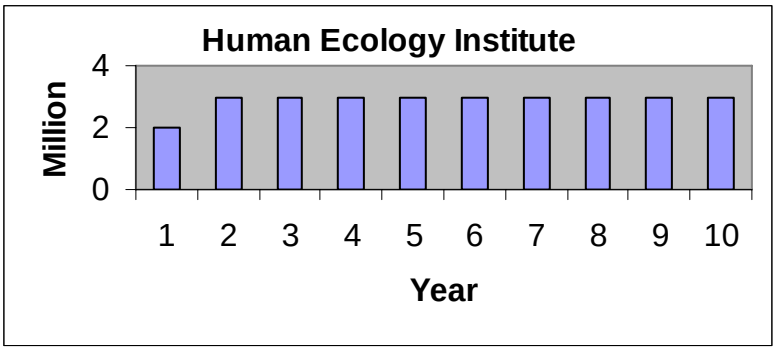


Figure 8

		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Human Ecology Center		2	3	3	3	3	3	3	3	3	3

Table 2

Section 3.2 Teacher – Staff Education and Professional Development

"Teacher education is probably the most important element of successfully integrating technology into our schools," Lewis Solmon.[13]

Definition and Scope

Teacher and staff include all K-12 school staff and administration whose professional activities effect student learning. This cadre may expand to include the parents and other community members who engage students. Education and professional development may be provided by pre-service education in colleges and universities; on-the-job training and education from mentors staff or peers; formal training and education during release or non-service hours in traditional classes or by using eLearning resources; and informal learning that uses the Internet and other sources to find data, information and resources.

Vision

Arizona teachers transform their practice to a higher level of professionalism with greatly increased student contact time. The technology part of eLearning delivers a tailored and patient student instructional interface which minimizes teacher lecture and clerical loads. With eLearning delivering formative assessments and removing most administrative loads teachers are able to deliver individualized real-time instructional decisions and support for their students. Teacher satisfaction soars as the new found time, eLearning tools and transformative professional skills allow them to develop effective relationships and create academic success with all their students.

Current Situation:

The Education Commission of the States rated two states (Indiana and Maine) as OK on professional development, eight adequate and the rest including Arizona "off track." Although 99 percent of teachers are "exposed" to professional development, only a third of it is connected to classroom applications.[10]

A survey of technology directors conducted by the Milken Institute found that many district computers were not being used. An important reason cited by fifty percent of overall respondents was that "teachers are not trained to use them."

A 1999 study had U.S. teachers averaging 21 hours of training on eLearning (15 percent of a single college semester course!). There is little indication that much has changed in five years. In the past, student teachers have received little about eLearning in pre-service education and field service. Teacher access to professional development in the form of eLearning in their classrooms is low. As a result, 90 percent of eLearning-savvy teachers report they are self-taught. Only 20 percent of teachers feel prepared to integrate eLearning into their classrooms.

A 2000 survey from the National Center for Education Statistics showed that teachers spend about a day or less in professional development in one content area. About eighteen percent of professional development was related to school improvement activities and only fifteen percent receive follow-up materials or activities. Teachers who felt the professional development improved their teaching averaged only twenty percent.[66]

Most workshop training is too short in duration and too limited in effectiveness. Teachers need to be taught much more than the entry-level use of computers. Even when they receive workshops on eLearning integration, there is little follow-up, their teaching environment is ill-equipped, and/or there is little mentor support for continuous on-the-job transformation.

Teacher Beliefs and Support: It is difficult for most teachers to cast off the legacy model and embrace the eLearning model of collaboration-inquiry-interaction. This is not surprising in light of inadequate modern classroom computers, narrow range of digital curriculum and spotty professional support and mentoring. Professionals in many other information-based industries had to labor over the past two decades to transform their practices from paper and pencil to computer-assisted workflow. But with adequate funding, the right computer equipment and software, and management support they were finally successful.

The transformation is risky, difficult, and time consuming. The teachers must believe that there will be significant benefits for their students, and they must have administrative support. Their beliefs will change at each stage as their experience grows. Observing successful models in practice allows them to look before they leap. Mentors are vital in changing teacher beliefs about eLearning.

What is Needed:

When teachers are taught how to use eLearning effectively, student academic performance improves. In one study, math scores jumped a half grade level (13 weeks). Ten hours of training is better than five or fewer hours. Rhode Island put twenty-five percent of its teachers through a sixty-hour entry-level course and provided notebooks and software for classroom and home. Email use jumped from thirty-four percent to 98 percent. On the other hand, novice eLearning teachers tended to focus on the multimedia, glitz, and technology--under-emphasizing content.

Teachers must be able to use eLearning for their own education and professional development. Completion of training in computer use, applications, and the Internet within the context of legacy education will be a necessary first step. As the eLearning foundation is developed, the focus will shift to learning how to use eLearning tools, methods and context to transform their teaching.

Apple Classroom Of Tomorrow (ACOT) developed a one-week practicum and four-week institute with one-year follow-up support. The teachers learned to develop successful learning environments for students including exploration, reflection, peer collaboration, authentic learning tasks, and hands-on active learning. What worked for students also worked for teachers. Their follow-on Project CHILD provided a year of training and coaching that extends to collaborative teaching strategies and research materials.

Recent Efforts: During the early 2000's teacher training by Arizona School Services through Educational Technology delivered a three-hour introductory and overview training module on using the Cox Education Network. Also, a 15-hour integration training module provided professional education to teachers on becoming eLearning practitioners. The allocation of $2 million for training of 44,000 teachers was about $45 a teacher.

Needs Served:

The Arizona eLearning transformation is designed to assure that all educators are educated, trained and motivated to use the eLearning tools and methods. The ten year population growth from 50,000 to 65,000 educators added to replacement for retirement and departure presents a challenge. The retention of educators at the top of their profession is just as severe. eSATS serves this need directly by creating the eLearning education and professional development curriculum framework and certifications, locating and vetting the resources, and providing mentors and adequate funding for education and professional develop for each teacher. The mentor system provides and additional career opportunity. The efficiencies and effectiveness of eLearning will fund a 20% additional (over cost of living) raise in salary for teachers as their eLearning qualifications increase. At 2% a year over ten years – this real increase in wages will assure attraction and retention of the best educator cadre in the country.

The transformation/creation of Arizona's education and professional development system will serve as a model for the nation. Major attributes include:

- Pre-service eLearning-based college education
- One master-mentor teacher per 50 school teachers;
- An integrated set of legacy and eLearning delivery means: classes, workshops, conferences, courses, on-the-job; just-in-time, future preparation, learn by doing, learn by thinking, formal, and informal.
- An integrated curriculum framework, certification and delivery system;
- All supported by an eLearning Education and Professional Development Institute.

Design Specification:

Teacher and staff professional development and education for each educator within their individual learning plan for their domain which includes:

Pre-service education: A significant percentage of eLearning-savvy entry-level teachers are needed within four years of the launch of eSATS. Arizona's university and college teacher education programs must be rapidly transformed to deliver education on eLearning theory, pedagogy, process and practice.

Master-mentor Teachers: Teaching is an intensely human activity that addresses learning as an art form. As in any profession there is a small cadre of masters of their practice and art. Master teachers take many years to develop and seem to have unique inborn talents. eSATS will require at least 1000 of these experts (2% of teacher population) in the schools to support eLearning adoption and continuity state wide.

In-service professional development and education: Comprehensive and continuous professional development for teachers and staff members is absolutely crucial for eSATS success. Most teachers have some experience in using computers for office applications, email and the Internet. But eSATS will require them to learn a much higher level of understanding and skill to transform their classrooms into eLearning environments. eLearning professionalism must be achieved not only by the academic staff but also by information technology staff, librarians, digital curriculum

experts, and school leadership. eLearning technology will deliver Web-Internet-computer-digital content, courses, knowledge, and digital curriculum through online learning with chat and expert access, and collaborative learning in the teacher's classroom, study area, and home. Teachers will have to learn to use these continuously improving tools and resources to the fullest.

Curriculum framework: will reflect the International Society for Technology in Education professional development standards along the eLearning skill continuum from entry to invention or to Target Tech. The curriculum framework will include Arizona Department of Education and district certification for learning achievements along the continuum. Legacy classes and courses will blend with eLearning. The scope and sequence of curriculum offerings will address the individual needs of the educator and evolve over time.

eLearning Education and Professional Development Institute: This institute will deliver support to both student and in-service teachers as they enter the world of K-12 eLearning. The eLearning Education and Professional Development Institute will collaborate with the Human Ecosystem Center and the Digital Curriculum Institute as they develop and evolve the eLearning ecosystem policy and design tools and digital curriculum for teachers and staff professionals. eLearning Education and Professional Development Institute will be formed as a partnership between Arizona Department of Education and Arizona Board of Regents. The initial task will be to develop a comprehensive curriculum framework for educator education and professional development from pre-service to master-mentor levels of expertise. It will research and develop certification requirements to be implemented by Arizona Department of Education. eLearning Education and Professional Development Institute will also find and assess all sources of eLearning education and professional development that is accessible by Arizona teachers and staff. eLearning Education and Professional Development Institute will provide a recommendation service to support teachers and administrators.

Design Details:

The eSATS professional development system will shift from isolated learning and occasional workshops to continuous eLearning. The eSATS curriculum frame includes both teacher standards and certification criteria. The emphasis will be on collaborative structures, diverse and extensive professional-learning opportunities, and an emphasis on teacher accountability and student academic results.[67]

Education and Professional Development: The curriculum for Arizona teacher professional development over the five eLearning developmental stages is still incomplete. The eLearning Education and Professional Development Institute will be responsible for accelerating the development of a system that full serves all five stages. Their curriculum experts will seek out and engage the accessible universe of legacy and eLearning sources.

The legacy model of formal teacher professional development expects the typical learning task for the teacher to be the approximate equivalent of college course per year. If we used this model for eSATS the number of classes to deliver one course each for 50,000

teachers would be 1,000 per semester. One thousand new eLearning classes is a significant challenge for legacy college education. But the emerging world of online professional development provides another means to meet this 1,000 percent increase in demand.

A wide variety of public and private sources exist. School districts provide in-house training-education with the teachers being relieved by substitutes. Many in-state and global online courses are available. Sources include community colleges, ASSET, Arizona universities including NAU's K-12 Center, and private colleges such as University of Phoenix Online and Grand Canyon University. Other online sources include the Arizona Regents Virtual University now based at Northern Arizona University and Western Governors University[68].

A number of Greater Arizona eLearning Association eLearning enterprises are expected to invest to develop courses and provide instructors and facilities to capture a piece of this professional development business. With their online capabilities, the demand this local market would drive a global market with Arizona companies. They could be first into the market with significant experience advantage over global competition.

Mentors: A district-based cadre of master-mentor teachers will provide just-in-time/on-the-job eLearning education and training for Arizona's 50,000 teaching staff. The ratio will be one mentor per 50 teachers. The average student/teacher ratio (including special programs, librarians, etc.) is 18. A school with a population of 900 students would have 50 teachers and require one master-mentor teacher.

With more than twenty years of experience with educational technology in Arizona a small cadre of teachers has developed to master-mentor level. This cadre must be increased to 1,000 within four years to fully support eSATS implementation. This cadre will revitalize teaching and present an exciting career path opportunity.

Teacher Salaries: The hiring and retention of the most able teachers will be easier with the nation's best professional development and eLearning system and the day-to-day support from mentor teachers. The productivity of these teachers is expected to slowly increase over the next ten years. The less able teachers and those who decide to remain legacy teachers will seek other opportunities. As with other information-based industries, the workforce will slowly shrink while proficiency, productivity, and salaries increase for the most able teachers. The expected productivity increase would be 10% over ten years based on teacher-student ratio. The salary increase has been set at 20% above inflation adjustments over ten years to match individual teacher success moving up the eLearning certification ladder.

Proficiency Stages: Teacher professional development starts with training on using the Internet and productivity software applications. It evolves to formal teacher education, mentoring, and on-line eLearning anytime, anyplace. Arizona Learning Technology Partnership Inc. (ALTP) and CEO Forum separately developed four similar stages of teacher professional development and transition. Arizona School Services through Educational Technology and ALTP integrated the results of the following four major research, study, and analysis efforts into a digital curriculum framework[2]:

- The **International Society for Technology in Education** set of student, teacher, staff, and administrator professional development standards and National Educational Technology Standards, Spring 1999 that were submitted to the National Council for Accreditation of Teacher Education and Road Ahead studies[18,56];
- The **CEO Forum**'s *STAR Report – School Technology and Readiness*[1] that addresses the need for technologically aware personnel in the workforce;
- A decade of research by **Apple Classrooms of Tomorrow**[19] providing a qualitative and quantitative analysis of technology integration and the required professional development;
- **The Milken Exchange**'s *The Seven Dimensions for Gauging Progress*[20] for identifying the need for technology in schools, a method for determining that need and a set of indicators for evaluating the use of technology by assessing the following: learners, system capacity, community connections, technology capacity, and accountability.

eSATS design team elaborated on the ACOT development stages of teacher-staff professional development and education within the systems design:

- **Entry**—Educators learn the basics of computer, productivity applications such as word processor, spreadsheet and presentation; and use of Web-Internet-networks with a browser. They have a computer for their use. Their students have limited use of a computer lab, but the teacher is not directly engaged. Students that do not have computers at home learn to use computers in school;
- **Adoption**—Educators move from the initial struggles to successful use of technology on a basic level including student records, media access and presentation from their projector, and PowerPoint presentations. They have mastered the subject matter of their teaching discipline, there are modern, multimedia computers in the classroom with one for eight students;
- **Adaptation**—Educators adapt eLearning into legacy classroom practice. The focus for the educator is enhanced student productivity to academic standards by using drill and practice applications, word processing, spreadsheets, PowerPoint, email, and Web-Internet. Teachers use computers to enrich digital curriculum and use web sites for reference material. Students learn to learn in a media-rich learning environment and are mastering the basics of 21st century information worker skills with one computer for four students;
- **Appropriation**—Having achieved mastery over a wide range of eLearning tools including digital curriculum-based instructional and assessment software, educators use it "effortlessly" as a tool to accomplish a variety of traditional instructional and management goals. For example formative assessment programs for essays unload the teacher to spend more time in direct guidance of each individual student. Students show marked improvement in their academic performance. Teachers have mastered the source locations and knowledge within the digital curriculum of their teaching discipline. Students are mastering the higher thinking aspects of the 21st century skills with eLearning support;

- **Invention**—Educators are engage in the development and adoption of eLearning environments focused on collaborative small groups and the individual student. With eLearning assessment and delivery support, including intelligent tutors and simulations, learning becomes collaborative, interactive, and responsive to individual learning needs. Student assessment systems support real-time coaching and learning and mastery testing at the end of the unit or semester. Enabled by the eLearning technology, the educator redefines the learning environment and teaching methods to eLearning (collaboration, inquiry, interaction, exploration). Students learn to manage their own learning in a constructive mode at their best pace while they enjoy significantly increased student achievement. The educator has a transformed practice which includes significantly increased student contact and guidance, and may include production-web publishing of eLearning grade digital curriculum.

Appendix D has the details on the ISTE professional development standards over these five stages for not only teachers but technical support and leadership:

- Technical Support
- Advanced Technical Support
- Teaching Fundamentals
- Teaching Integration
- Leadership

There is striking evidence supporting the need for principal and administrative support. Leadership must be committed to the transformation and maintain its instructional leadership in this transformed mode. Principals must provide time for professional development and education, give recognition for success, and give authority and flexibility for scheduling and curriculum objectives. Certification and pay scale criteria must be changed to reflect successful eLearning professional development and success in the classroom.

The CEO Forum[1]'s target tech teacher (TTT) functions at the Appropriation and Invention capability. This teacher will be highly effective in an environment that has: student-centered learning, multi-sensory stimulation, multi-path progression, multimedia, collaborative work, information exchange, active/exploratory/inquiry-based teaching, critical thinking, and informed and data-supported decision making, proactive/planned action and authentic environments, and real world context.

Funding Models:

The budget issue that arguably is most critical to a school district's ability to achieve its technology goals is staff development. To underscore this point, the U.S. Department of Education had recommended that school districts set aside 30 percent of their technology budgets for staff training and development. The Massachusetts Software Council points out that many businesses match every dollar they spend on computer hardware or software with another dollar for training. They recommend that at least one-fourth of a school's technology budget be set-aside for that purpose. Unfortunately ratios like this

only work if there are adequate investments in computers, connectivity, digital curriculum and technical support.

A large component of in-school staff development cost is substitute teachers. The teaching staff must have time for professional development during their regular work hours. In a well-publicized model[21] of school-technology costs, http://www.uark.edu/mckinsey/ McKinsey & Co. assumed hiring substitute teachers would cost $100 a day. Also, 1.5 full-time staff members would be needed to conduct training.

Another model developed by Integrated Technology Education Group, LLC, for the National Center for Supercomputing Applications calls for a minimum of five days of training per year per teacher and two days per year per administrator, as well as an additional six days per year of informal peer-to-peer training. This is just for Internet connectivity. The model adopts 30 percent of the computing budget for staff training as the goal to which districts should aspire, but considers 15 percent to be the minimum acceptable.

A 1996 RAND study of eight pioneering high-tech schools found that the cost of staff development ranged from $15 to $35 per student per year, with most schools spending about $25. As a share of their technology budgets, the percentages ranged from 22 percent to 5.5 percent, with the average being about 10 percent. This $400 per teacher is approximately 20 percent of the $2000 annual cost per employee invested by information-based industries.

Smart Valley, a 1990's initiative by Silicon Valley companies to network schools and other community institutions in that area, approached the issue another way. It recommended in a school networking guide[22] that "an average starting point" should be to allocate approximately $1,500 per year for each person requiring training.

An early 1990s study assumed that the typical school with 700 students and 33 staff members would spend $2,000 per staff member for staff support, materials and mileage and $35 an hour for trainers (with a projected 2,000 hours required per school).

During the 2003-2004 school year, United States schools spent an average of $103 per student on educational technology.[85] The break out was $71 on computer hardware, $17 on software/content, $9 on outside services including connectivity and only $6 on staff development. With 18 students per teacher, the current funding for educator profession development was $110 per teacher, not the $2000 needed for a high-end information professional.

In general these analytical and field studies conclude that eLearning investment should be approximately 30 percent equipment and 70 percent connectivity, professional development, technical support, and digital curriculum (content and software). Currently schools spend less than 6 percent on professional development. There are four reasons:

- Funding for eLearning is, on average, only 20 percent of the level needed. Without Target Tech levels of equipment in the classroom most teacher professional development cannot be effectively applied;
- The eLearning mental model of teacher-student focused learning is still struggling to replace the mental model of computers and wiring;
- The concept still prevails that all the school has to do is teach "computers." The eLearning model of enhancing teaching if all subjects with computers has not yet universally penetrated. Unfortunately most of the State academic standards only include teaching about computers – a subject of importance in the 1980's but not very relevant today. A vast majority of students enter school with internet skills well in hand. They prefer multi-media to books and blackboards[76];
- The persistent notion is that computers in the classroom are primarily for administration and summative assessment purposes, not formative assessment and instructional.
- The most recent edition of Education Week's annual Technology Counts 2005 issue[85] addresses the switch from instructional technology in the classroom and teacher professional development of prior issues to data systems to support the expansive reporting requirements and ambitious student-achievement goals set forth in the federal No Child Left Behind Act.

Cost:

Teacher and Staff Education and Professional Development: The 1999 Arizona Learning Technology Partnership decision support model written in Excel was used to simulate the growth and flow of the Arizona teacher population within the five eLearning development stages for the next 20 years. The number of teachers in Arizona has been growing at a rate of approximately 1500 teachers per year. The additions are a mix of college graduates, reentries and out-of-state hires. The deletions are a mix of retirees; teachers who decide to quit or change careers; and those leaving Arizona. It includes the distribution of teachers within five teacher proficiencies stages. The current requirement for net teacher inflow to Arizona's districts is 5000 per year. By using historical data, current year data, forecasts of student graduation population growth, and years it takes to train-educate-mentor a teacher along the stages of proficiencies, simulations of future cadre capability stages were calculated.

Professional development costs for teachers at each level of eLearning capability can be specified. Costs can also be differentiated between studying for certification for the next level and maintaining capability at the current level. The cost effectiveness of added retention and acceleration of qualification could also be studied. This decision support model was used to determine the detailed funding required for the teacher professional development for the ten years of the eSATS design.

The simulated analyses resulted in the need for approximately $1,200 per year of direct cost per teacher for in-service professional development. The $60,000 per year per master-mentor teacher cost averages to $1,200 per teacher. This investment is a factor of twenty larger than current average support for teacher professional development and education at approximately $110 a year.

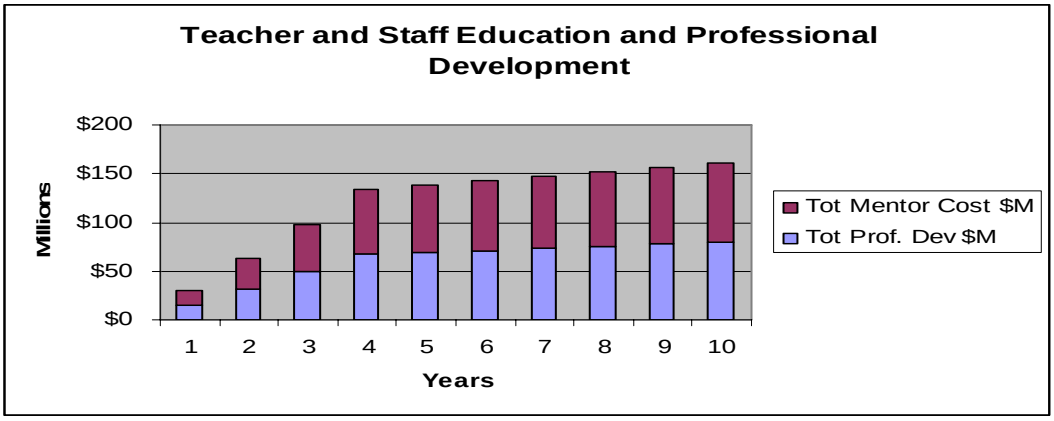


Figure 9

	45000	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Percent Engaged	8%	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%
Teachers & Staff	49815	51309	52849	54434	56067	57749	59482	61266	63104	64997	66947
Prof. Dev/Teacher	1200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200
Tot Prof. Dev $M		**$15**	**$32**	**$49**	**$67**	**$69**	**$71**	**$74**	**$76**	**$78**	**$80**
Mentor%	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Teacher Mentors		257	528	817	1121	1155	1190	1225	1262	1300	1339
Cost/Mentor	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Tot Mentor Cost $M		**$15**	**$32**	**$49**	**$67**	**$69**	**$71**	**$74**	**$76**	**$78**	**$80**
Total	**$M**	**$31**	**$63**	**$98**	**$135**	**$139**	**$143**	**$147**	**$151**	**$156**	**$161**

Table 3

eLearning Education and Professional Development Institute: Arizona Department of Education and Arizona Board of Regents are each funded up to $8.5 million a year for the eLearning Education and Professional Development Institute. The $17 million total is based on the need for a core staff of 50 digital curriculum experts and 50 outreach professionals to work statewide with teachers and staff. Cost of each professional staff member with their expenses and overhead is estimated at $125,000 per year. This funding also supports the Arizona Department of Education eLearning educator certification operation. About $4.5 million is expected to be used by the Arizona Board of Regents for transforming their colleges of education with an eLearning curriculum.

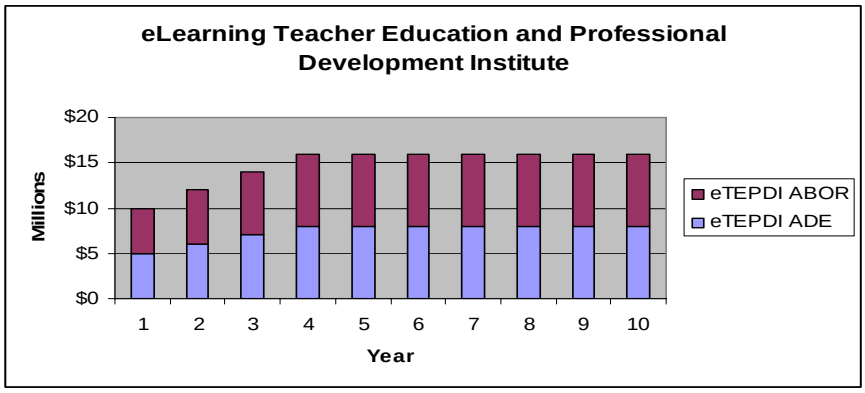


Figure 10

		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
eTEPDI ADE		$5	$6	$7	$8	$8	$8	$8	$8	$8	$8
eTEPDI ABOR		$5	$6	$7	$8	$8	$8	$8	$8	$8	$8
Tot eTEPD Institute $M		**$10**	**$12**	**$14**	**$16**	**$16**	**$16**	**$16**	**$16**	**$16**	**$16**

Table 4

Teacher Salary Increases Along the eLearning Certification Path: As teachers traverse the levels of eLearning proficiency as certified by Arizona Department of Education they will be eligible for salary increases of a total of 20% over ten years. The cost will be low during the eSATS bridge phase but then grow as K-12 eLearning becomes operational statewide.

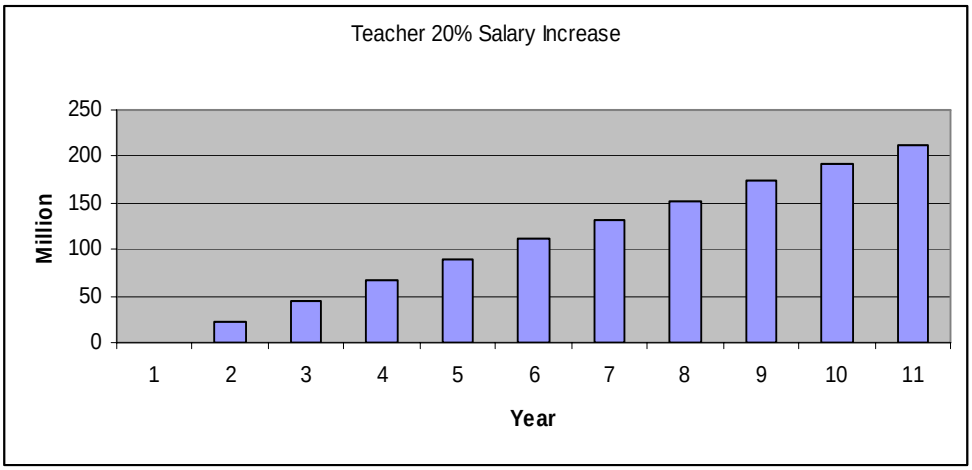


Figure 11

Teacher Salary		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Average Increase			2.0%	4.0%	6.0%	8.0%	10.0%	12.0%	14.0%	16.0%	18.0%
Yr. Early Graduation			1.2%	2.4%	3.6%	4.8%	6.0%	7.2%	8.4%	9.6%	10.8%
Legacy Teachers			52849	54434	56067	57749	59482	61266	63104	64997	66947
eLearning Teachers			52215	53128	54049	54977	55913	56855	57803	58758	59717
Legacy Cost	$M		$2,892	$2,979	$3,068	$3,160	$3,255	$3,352	$3,453	$3,557	$3,663
eLearning Cost	$M		$2,857	$2,907	$2,958	$3,008	$3,060	$3,111	$3,163	$3,215	$3,268
eLearning w/Increase	$M		$2,914	$3,023	$3,135	$3,249	$3,366	$3,484	$3,606	$3,730	$3,856
Net Increase Cost	$M		$22	$45	$67	$89	$111	$132	$153	$173	$193

Table 5

Section 3.3 Digital Curriculum

Definition

eLearning Digital Curriculum as Innovation Driver: Curriculum has several levels of definition. Globally it is everything and everyone in the student learning environment that supports learning. It can also be the scope, sequence, process and content delivered to the learning experience. Used as the result curriculum is the skills, information and knowledge learned by the student.

eSATS focuses on digital curriculum design that uses the Internet, software-based systems and content that supports learning. Real time formative and summative assessments are a critical part of digital curriculum. Other aspects of the holistic view of curriculum (teacher, student's human ecosystem, computers, connectivity, and summative assessment to standards) are addressed in the other sections.

About 7,000 years ago writing transformed curriculum. Paper emerged in the first millennium current era. The printing press followed in the 1400s, reducing the cost of books by a factor of 400. Various analog inventions such as the lead pencil, blackboard, movies, television, overhead display equipment, and programmed learning machines enhanced legacy K-12 curriculum but did not produce transformation. Digital curriculum was invented in the mid 1970's and emerged as software on networked personal computers in the early 1980s.

After 25 years, digital curriculum is finally on the upswing part of its 50-year innovation cycle. These time estimates are based on a large body of innovation life-cycle research for other technologies. Significant advances are expected in the next ten years. These digital curriculum advances will be based on research that integrates advances in information technologies with behavioral and cognitive science into eLearning theory. Biotech neurological research is also emerging as a source of eLearning theory.

K-12 eLearning will benefit from cross-industry adoption of digital curricula. The four major eLearning industries are at different positions along the eLearning innovation cycle. The military-simulation industry has received 80+ percent of federally funded eLearning research dollars, creating an accelerating force behind the federal government workforce eLearning training efforts. The other markets— workforce, higher education and K-12 – lag in adopting research-based digital curriculum.

eSATS educators are expected to use the full range of curriculum, whether digital or analog: CD, DVD, textbooks, Internet, film, worksheets, video, email, computer simulations, databases, audio and streamed discussions. Over the next ten years most the media based curriculum is expected to become digital. Since analog curriculum learning objects are well known the focus of the eSATS design will be on the aspects of the digital curriculum.

Societal Changes and Economic Needs Require Digital Curriculum: For the first time in history a society has demanded that "No Child be Left Behind." Some children come to school from homes with years of experience of 1:1 computing and video games. Immigrant children need to quickly learn English. The competitive global economy demands a workforce that excels by using the tools and practices of the information age. Year by year the family- community-civic life depends more and more upon digital age resources. The new concept of life span learning requires a continuum of eLearning.

Processes within a pedagogical framework are the heart of curriculum. Today's K-12 education has finely tuned the lecture-recitation-seat work pedagogy. K-12 eLearning is better adapted to the drill and practice pedagogy of computer based instruction for basic skills and the collaboration, inquiry, and interactivity pedagogy of learning for higher level skills. The constraints of learning time and funding resources foils labor-intensive traditional education attempts to address these needs. If K-12 is to be transformed meet the needs of the societal needs of the information age, then only digital curriculum with an eLearning has the capability to deliver a time and cost effective solution.

Transformation with eLearning Digital Curriculum: The mastery of K-12 education by a single student addresses a very complicated set of learning objectives, motivations, abilities and constraints over a typical 12 year period. Appropriate digital curriculum can be used individual student immediate learning objective and for a total course of learning.

Digital curriculum delivers with patience, privacy, and economy. Built-in assessment delivers continuous feedback. The student stays on track and engaged. Drill and practice are effective. Progress monitored daily or even hourly supports and motivates students, and delight teachers. With digital curriculum support the teacher is free to engage the student directly, with adequate time to be effective. Artificial intelligent tutoring systems provide individual support. Simulations are reproducible, visible, safe, accessible, and cost-effective compared to real environments. eLearning is also accessible outside of the classroom increasing student time on task.

Digital curriculum supports the constructivist mode of higher-level learning in which students manage their learning, collaborate with peers and experts, and engage in project-based and exploratory learning. Digital curriculum provides the means to expand the K-12 teacher-centered pedagogy to one that is truly responsive to the learning needs of the individual student.

eLearning delivery of digital curriculum with scope and sequence provides a means to address the attributes of 21st century learning.[72] Scope defines the depth and breadth of a specific course of learning. Sequence facilitates learning effectiveness for the student by providing continuity between prior and succeeding courses.

Five Attributes Of Digital Curriculum

In the eSATS environment, the learner is immersed in 21st century learning tools. Student skills are automatically picked up and honed to individual needs throughout the higher level eLearning supported processes. Core subjects are learned from eLearning in the basics areas and with eLearning in the higher level areas. 21st century context is provided

by the Web, which can bring the world into the classroom. Content is accessible from global sources using digital curriculum registries to locate knowledge repositories.

Individualized tutoring: The use of simple computer-based instruction in the 1980s decreased the time to learn by 30 percent or increased learning 30 percent in the same time. The effect of this individualization is “C” students performing at “B” levels. Many experimental studies over the past 75 years have compared one-on-one tutors with classroom instruction, finding a two letter-grade advantage to the tutored students. eLearning has the potential to bring the power of human tutoring all students.

Adaptation and interactivity: “Branched instruction” adjusts its content and pace for individual learners. In branched instruction, prior subjects or prior years can be made available, aiding mastery of current materials by instant “relearning-refreshing” from prior eLearning exercises. Teacher support can be focused on the needs of the current task. Branched instruction has been compared to strictly linear presentation of the same material using identical delivery devices. Studies found between 1.72 and 3.16 times more learning with branched approaches, indicating the value of adaptation and interactivity in instruction.

Intensity of instruction: A student within typical classroom instruction is required to answer an average of about 0.11 questions an hour. In tutored instruction, the number of questions an individual student is required to answer ranges from 117 to 146 questions an hour. Some technology-based instruction averages as many as 120 questions during 12-minute sessions. The intensity eLearning-based instruction can significantly exceed that of classroom instruction.

Pace of instruction. The time the fastest K-12 student takes to achieve mastery of a typical subject compared to the time needed by the slowest student averages 5:1. In grade three it is 3:1, increasing by grade six to 6:1. A study with graduate students learning the programming language LISP resulted in a pace ratio of 7:1. With a fixed allotted time, the fast learner wastes time, and the slow learner never has time to master the subject. Learning pace is also subject-specific. A student can be a whiz at math and find it very difficult to learn Spanish. eSATS is designed to reallocate wasted time from rapidly-learned subjects to subjects that require more time. The result is a higher level of mastery to academic standards for students across the board. The bright students are not bored and stay engaged with their education. The less academically able are motivated by success to academic standards and stay in school.

Pace is recognized in work force eLearning. Instructional objectives are held constant. The Department of Defense regularly bases its eLearning bids on a 50 percent reduction in time to learn compared to legacy instructional methods. The military has always trained to mastery.

Teacher Performance: K-12 eLearning includes three overlapping digital curriculum areas: education, performance enhancement, and information technology (IT) training. As eLearning evolves, teacher and student will be immersed in a mutual learning situation. The student will be using eSATs to achieve mastery learning of the K-12 curriculum. The teacher will be transforming her teaching practice via learn-by-doing

within performance aids in the student-classroom context. Information technology train-by-doing is automatically achieved as the teacher and student use all aspects of IT during the years of K-12 eLearning.

Two types of eLearning will significantly enhance the practice of teaching. The first is the accessible, effective, equitable and efficient education teachers will receive during professional development using eLearning. The other is teacher performance support. Statistically-based algorithmic procedures, delivered by eLearning, have been found superior to the judgment of individual humans in a practice setting. They will cover the full range of options with descriptive and prescriptive approaches. Modeling capabilities used on intelligent tutors can be used to design these systems for teachers. eLearning-based performance aids have been found cost effective.

Teachers must maintain control of student learning decisions. Only a professional teacher can teach and guide a student with intuition and understanding that is based on social roles, identification of alternatives, timing of interventions, etc. These are too elusive to be captured in algorithms. But immediate student performance data to support teacher decisions can be invaluable. A typical successful application in the medical field is the use of personal digital assistant (PDA) technology with heuristics for inclusion-exclusion of patients in clinical trials. This solved a problem for physicians who found that the traditional use of Internet or journals to track clinical trials was an unmanageable solution. The same type of “guide-on-the-side” can be developed to support teachers as they make decisions about individual students.

Types Of Digital Curriculum And How They Work:

Why Does eLearning Work?[32, 35] The emerging vision of digital curriculum in K-12 education is led by more than forty years of university, military, aerospace, and medical research. A number of recent studies by the Office of the Deputy Undersecretary of Defense, Science and Technology have provided a rationale for expected results from adopting digital curriculum within eSATS.

Education From Computers => Basic Skills: At first, K-12 education focused on computers in isolated computer labs functioning in tutorial mode or running simple productivity applications. Students learned from tutorial computers. These digital curriculum systems evolved under a number of names: computer-based instruction (CBI), computer-assisted instruction (CAI), Integrated Learning Systems (ILS), or intelligent tutoring systems (ITS). This form of digital curriculum, while effective for basic skills drill and practice, does not address social groupings and is not as helpful for high-level skills. But it remains effective for increasing academic performance in the areas addressed by high stakes testing.

The research-based Cognitive Tutor program for algebra has demonstrated a 25 percent increase in student skills and 100 percent increase in problem solving, along with higher student retention and attendance.

The West Virginia Basic Skills longitudinal initiative on reading, language arts, and mathematics provides computers-connectivity, teacher training, and instructional software

in the classroom. Starting with kindergarten (1990), this cohort eventually reached fifth grade. Testing along the six-year path and the 5th grade SAT-9 verified that even this minimal eLearning adoption produced significant performance gains in basic skills.

Over the next ten years. West Virginia's rank in student achievement rose from 33rd to 11th.[11] A decade-long similar study from kindergarten to 5th grade demonstrated higher test scores and better discipline. There were positive results in both low- and high-achieving schools. The first six years of eLearning success carried over to the traditional middle school, with students taking tougher classes, making better grades, and scoring higher on standardized tests.

Meta-analyses of data from 1985 to 2000 over a wide variety of eLearning basic material instruction tutoring showed a range of percentile gains from 9 percent to 22 percent. This equals one letter grade increase in academic performance. The typical C student would be performing at a B level. A state at the 50th percentile on standardized tests would move up to the 64th percentile. This data applies to all major subject areas, preschool through higher education. With Arizona state academic standards focused on standardized achievement in the basic skills, the drill and practice attributes of eLearning would be the primary state ranking benefit.[36]

Education With Computers => Higher Level Thinking: As the Internet and World Wide Web began their rapid growth in the mid 1990s, a type of digital curriculum different than computer based instruction emerged. Equipped with powerful calculation, word processing, multimedia creation/presentation, visualization, and real world data search applications, the student was freed to create problem-solving strategies and developing deep understanding. These proved most effective when access was in the classroom rather than in the computer lab. The classroom has more opportunity for teamwork and social groupings. A classroom with an engaged teacher is better for ability grouping and age-grade grouping in small collaborative teams. The constructivist aspects of learning higher level skills are defined more by the student than driven by the computer in the basic skills mode.

Specialized eLearning programs can analyze the student's work and give immediate coaching. An essay-grading program provides almost instant feedback to the student, who must no longer wait from Tuesday to Friday while her teacher has laborious grades thirty essays.

Instruction can be changed by removing scaffolding to allow the student work on a more complete aspect of the concept, or by adding scaffolding to narrow the student's focus to a critical component. The broader learning context (classroom to community) expands the complexity of learning, but benefits are more difficult to measure.

A large number of studies since the 1920s supported "time-on-task" as the primary independent variable in education. We now know that there are additional multipliers within eLearning. The student continuously engaged with eLearning packs more learning into a given time span. Interactivity, which continuously engages the student, is also a multiplier.

Researchers focused on eLearning found that the improvement in higher level skills was significant. Students gather, organize, and analyze information and solve problems. Teachers and students control the digital curriculum and instruction. Browsing the Internet and email collaboration greatly expand content and motivation of the student. The greatest benefit is the ability to tailor eLearning to the individual student need, from handicapped to gifted.[36]

Assessment of higher level skills is more difficult and less quantitative than basic skills. One longitudinal study addressed project-based eLearning based on multimedia production. Teachers became facilitators, and the students formed collaborative groups to address complex projects. The study's students learned the basic skills at the same level, but outperformed the other students in all production aspects.

A study of 300+ research reviews by the Software and Information Industry Association (SIIA) found that eLearning also had a significant effect on student attitudes toward learning, self-confidence, and self-esteem. eLearning students went beyond assignments and also used more of their free time on school work. Dropout rates, attendance, and feelings for responsibility all improved.

Union City, New Jersey schools implemented Project Explore, which used digital curriculum adoption as the center for transformation of the classroom, school, and district. Simultaneous changes were made in digital curriculum, professional development to change teaching process, scheduling and assessment, and parent-community support. The transformation, which included Web sites, email, individual student and staff portals, access to online professional development anytime-anywhere, and linking of home computers increased middle school state-mandated test scores from 30 to 50 percentile.

The IBM Reinventing Education program showed that integrated eLearning with reorganized teachers and digital curriculum produced better results than eLearning standing alone in a conventional classroom setting. Changes such as longer class periods and project-based learning work when there is a clear plan for improving student learning and articulation of this plan by all stakeholders.

The Apple Classrooms of Tomorrow (ACOT)[19] ten-year study showed that students flourished as teachers learned when and when not to engage eLearning. Continuous teacher collaboration was very effective. As the students were engaged in their collaborative teams and on the computer, there was much more time for individual student engagement and assessment by the teacher. The individual interests and abilities were exploited. Interaction, motivation, and engagement time (time-on-task) were up. ACOT found that the graduates from five of their schools throughout the United States routinely employed investigative, collaborative, technological, and problem-solving skills uncommon to graduates of legacy high school programs. These "workplace" skills were similar to the 1990s SCANS criteria from the U.S. Department of Labor.

A rich mixture of commercial and free available digital multimedia instructional products is available. Applications existing or under development support collaboration, correspondence, Internet access, online courses and subjects, presentations, inquiry, analysis, content production, tutoring, learning management, and assessment—both formative and summative.

Learning Systems:

LMS, and LCMS: Learning Management/Content Systems provide a means to automate the management of eLearning. LMS/LCMS deliver a wide range of services to support: student learning time management and recording, individual interfaces to digital curriculum, group interaction, Shareable Curriculum Object delivery, producing and recording assessments, continuously updating the student profile and proficiency, and automatic record creation and submission for the teacher. There are a several standards that attempt to assure compatibility. SIMS is the most common in K-12 education where SCROM leads in the university and workforce markets.

Digital curriculum Sources:

K-12 has a global set of vendors who deliver digital curriculum-based software products and Internet-Web-based media and resources including online learning. This industry is growing over 20 percent a year. There are a number of Arizona companies in this field (Appendix C) including the world's largest K-12 digital curriculum provider. An array of digital curriculum is also available from the public sector and no/low cost Web sources such as www.Beyondbooks.com. Some is open source and some proprietary.

Ultimately teachers will be able to assemble digital curriculum to meet the immediate needs of individual students. But initially digital curriculum will be course length courseware or support materials. As the industry matures teacher eLearning expertise will grow and the digital curriculum metadata registry system will become operational. Teachers will be able to assemble digital curriculum over individualized student scope and sequence using Sharable Curriculum Objects. eSATS uses the Shareable Curriculum Object to mean Sharable (Digital) Curriculum Objects. These digital objects may go well beyond content to include scope and sequence, formative assessment, scaffolding, Internet communication, coaching and teacher development attributes.

US DoE maintains the Educational Resources Information Center (ERIC) which is the world's largest educational database with one billion bibliographic records.[60] A $34.6 million five year contract was recently awarded in 2003 to develop and operate a new database system to provide educational materials directly through the Internet. This information on education will be accessible, either free or through commercial firms depending on who owns the material. Research on curriculum and educational processes will be represented in journal articles, abstracts and full text.

Arizona K-12 Digital Curriculum:

Over the past twenty-five years digital curriculum adoption in Arizona has paralleled that of most other states. Each district has adopted digital curriculum of a wide variety of types and sources. Without detailed data, the eSATS design team does not know how or what digital curriculum is being used. Arizona is probably in the middle of the pack, with a number of notable school or district implementations. Some districts stand out as well ahead of the curve, but other states also have leading pilot and adoption programs. The following Arizona examples are representative, but many districts have had similar success with digital curriculum.

Wilson Elementary: Wilson Elementary K-8 district, with 1400 highly transient students, is located just north of Phoenix Sky Harbor Airport. In the early 1990's it installed 1:1 computing for all students and used the Jostens Integrated Learning System (ILS) digital curriculum. Prior to implementation the district was dead last in academic performance among 125 Arizona elementary districts. But after implementation its eight grade graduating classes tested in the top half of the twelve schools matriculating freshmen to Phoenix Union High School District.

State Wide Cox Education Network: In the early 2000's Arizona achieved temporary national leadership in provisioning digital curriculum through the School Facilities Board's Application Service Provider initiative. This Application Service Provider portal—the largest of its time – provides email accounts, portal interfaces and digital portfolio storage for up to 1,000,000 students and educators.

LearningStation delivered productivity and instructional applications over the Cox Education Network. More than 250 educational titles from 15 educational vendors were included in the base package of resources. Examples include INNOVA Multimedia, Learning Odyssey, and Alfy Web applications in language arts. Math has INNOVA Multimedia. Others include Graph Club, Kidspiration, Brainium, and AIMS Elementary 100 Video Library. Premium services could be purchased by the school districts for delivery through the Application Service Provider.

Ten thousand additional titles from 75 vendors, five student information systems, three student tracking and assessment systems, and teacher resource management tools were available. The Application Service Provider model delivered programs to schools on a subscription basis. Instructional applications, content, and digital curriculum on outside database file servers are integrated with the school/districts' software to support classroom learning. Digital curriculum selection focused on academic performance within the umbrella of Arizona academic standards. Bundles were available for a variety of subject areas in K-2, 3-5, 6-8, and 9-12 grade levels.

All applications were delivered with security over a Web browser on any Internet-enabled service. Titles are aligned to Arizona Performance Standards. FERPA and Child Internet Protection Act requirements were met: including firewalls, filtering, and virus control. LearningStation continued to upgrade its instructional desktop with additional functionality including an enhanced digital curriculum alignment tool to assist teachers in locating content aligned to state standards. Schools using the LearningStation Desktop have the AppTrax accountability tool call, which provides administrators with tracking data on computer usage by schools, by applications, and by student.

Virtual (On-Line – Cyber – Distance Learning) Schools: Arizona legislature authorized several pilot virtual schools and then upped the number to fourteen. These schools have specialized software programs that run within online courses or on a Web browser. Traditional school districts with virtual schools include: Lake Havasu Unified School District No. 1; Marana Unified School District; Peoria Unified School District; Tucson Unified School District; Tempe Union High School District; Deer Valley Unified School District; Mesa Unified School District. Charter virtual schools are Arizona Virtual Academy; Sequoia Choice School Arizona Distance Learning School; Chancellor Charter School at Sierra Vista; Pinnacle Education; Primavera Technical Learning Center;

Phoenix Special Programs dba Kids at Hope Online Academy; Humanities & Sciences of the United States, Inc.

Charter Schools: Since 1995 numerous charter schools such as PPEP TEC, Intelli-School and K12 Charter have used digital curriculum as the heart of their educational offerings.

Kyrene Teaches with Technology Project: Kyrene Elementary School District has provide to each classroom a system of one projector and five wireless notebooks. This allows flexibility to group students around collaborative digital curriculum tools with integrated lessons and assessments. Grade-level teams and peer leaders are supported by mentors. Microsoft Class Server is the learning management platform (LMP) that delivers online content and formative assessments.

Typical of the remaining 319 Arizona school districts: Paradise Valley District has acquired notebooks, an essential software suite and projectors for all teachers. Snowflake District has an exemplary rural adoption. The 2005 opening of a new Vail High School will incorporate 1:1 computing using the Apple Corporation system with a wide array of digital curriculum accessed from a range of sources. A similar Apple system is being adopted by a Navaho nation school.

Digital Curriculum Institute:

Most of the digital curriculum to be used within eSATS will be acquired in the future. As the level of digital curriculum acquisition of digital curriculum increases ten fold the system for acquisition and delivery becomes an important issue. At the State level, there will be a institute staffed by digital curriculum experts and eLearning instructional technologists. The Digital Curriculum Institute will manage the digital curriculum adoption process and recommend which digital curriculum products or online services will best serve the classroom teacher and student. Over the first several years of eSATS the Digital Curriculum Institute will be under developed by building its database and knowledge of all available digital curriculum and testing its extension services into the classroom. By year four it will be operational, providing and/or recommending appropriate digital curriculum for all K-12 learning situations. The Education and Professional Development Institute for teachers will be directly linked to Digital Curriculum Institute.

Digital Curriculum District Experts:[34] The curriculum experts and instructional technologist extension agents from the Digital Curriculum Institute must have their linkage counterparts in each school district. The deployment of high-speed computer networks will be completed by 2007 to serve every Arizona classroom. This ubiquitous resource opens the door for digital curriculum access; provided staff is available that knows how to vector the digital curriculum into the classroom. Information technology experts are required for installation and maintenance of computers, network infrastructure, and peripheral systems.

Digital curriculum specialists are required for installation and maintenance of digital curriculum, media, content, software, and application and assessment programs. The expertise of eLearning instructional technologists is needed to support the integration of digital curriculum into the student-teacher relationship. Together these three types of

district experts are responsible for supporting the teachers and their master-mentor teacher in transforming to an eLearning classroom. School district leadership is charged to build local staff expertise in these three areas.

Information Technology Role:

"Everything we said about the Internet is happening now." Andy Grove, former CEO of Intel [23]

The mental task of learning might be considered as the ultimate challenge for information technology. But information technology is no longer the lead technology for learning. That role is now taken by digital curriculum, where information technology plays a vital but supporting role. The task ahead is to concentrate on developing and adopting digital curriculum that fully exploits the power of emerging information technology.

For decades educators and all other information workers used information technology to automate manual tasks such as typing, calculating, drawing, communicating, and filing and retrieval of information. In the 1980's the personal computer initiated the eLearning transformation. The Internet-PC convergence was the 1990's transformative technology for eLearning access to content, information and communication.

Many information technologies are going mainstream during the implementation period of eSATS. Currently high-speed connectivity channels (DSL, cable, Ethernet, wireless and satellite) are main stream. The Web is the same age as color TV was when it turned profitable. The 64 bit chip that can produce cinematic displays rivaling the most sophisticated science-fiction movies, accurate speech recognition and artificial intelligence is being introduced in 2004 by Intel and AMD. 2006 video games will have 520 megs of RAM with central processing units having either three power PC's on a chip, or a single cell chip with one central and eight peripheral processing units.

The graphical user interface can now be replaced by a natural user interface. In a few years, flat displays will cover a wall for $500 and desktop displays will be the size and thickness of a poster board. By 2010 online books and other printed matter will be mainstream. Reliable speech recognition, which will provide direct student interaction with the virtual avatars (simulated people) will populate the Internet by 2010. Smart computers that can make adaptive changes and infer intent, analyze problems, make decisions and present an intelligent responses are also due by 2010. By 2014 virtual universities will deliver thirty per cent of courses. By 2016 virtual reality will be used for student education and teacher professional development. UCLA Cultural Virtual Reality Laboratory has a virtual 3-D ancient Rome on its web site, ready for a stroll through temples, monuments and plazas.[24]

Moore's law will continue to double computational power each 18-month period. By 2023, a $1,000 unit of computing will exceed the computing power of the human brain. This "unit" may not be an intelligent, self-aware cyber-human, but it will be able to provide profound levels of support to human cognitive learning. A novel system theory of the brain-mind is presented in "On Intelligence", Jeff Hawkin, 2005. Jeff has invested his fortune from inventing and programming the Palm Pilot interface into brain-mine research.

When computer systems emulate this brain-mind system of pattern recognition then we would have true artificial intelligence.

Emerging Digital Curriculum And Systems

There are a number of digital curriculum innovations under development. eSATS is designed to adopt these new products and systems when they become effective for K-12 education.

Distributed Simulation Environments will support experiential learn-by-doing. Much learning takes place in the real world through human interaction with the environment and other people. Learn my doing is much more than a buzz word. Human behavior representation is critical to flexible simulations that address individual learning needs. Synthetic characters must respond to verbal and non-verbal communication and actions in an authentic fashion at the appropriate level of fidelity. They may be instructors or team members. Digital curriculum will produce the most appropriate simulated environment filled with the student specific learning objects.

Shareable Curriculum Objects: The Advanced Distributed Learning (ADL) initiative is driven by a government, industry and academia coalition for effective transformation of legacy training and education to distributed global eLearning http://www.adlnet.org/. The lead sponsor is the Office of the Secretary of Defense. Its distributed eLearning environment will permit the interoperability of learning tools and Shareable Curriculum Object's on a global scale. The functional requirements include:

Accessible from multiple remote locations;
Adaptable to individual and organizational needs;
Affordable by increasing learning efficiency and productivity while reducing time and costs;
Durable across revisions of operating systems and software;
Interoperable across multiple tools and platforms;
Reusable through the design, management and distribution of tools and learning content across multiple applications.

A critical element for this digital system is the Shareable Curriculum Object. Each Shareable Curriculum Object has a digital metadata tag whose analog is the library book catalog card. Metadata ranges over K-12 specific hierarchies, categories, academic standards, key words, vocabulary, taxonomy, or tacit knowledge. Formative assessment may be imbedded in the Shareable Curriculum Object or be separate.

There has been significant development of the ADL concept and standards.[71] Its Sharable Content Object Reference Model (SCORM) is the interoperable standard for all digital curriculum to be used in their domains. Any SCORM compliant Shareable Curriculum Object can be run on any SCORM-compliant learning and/or content management system (LMS, LCMS). eSATS will accept SCORM compliance as one of its digital curriculum design standards.

Shareable Curriculum Object Metadata Repositories: [35] The IRS is an example of how to implement digital curriculum. All education within the IRS is under the SCORM industry standard that supports design, discovery, and reuse of Shareable Curriculum Object. It provides continuous education to 144,000 IRS employees. Its extensible architecture online is expected to eventually deliver education and training on dealing with income tax issues to millions of accountants and tens of millions of taxpayers. The IRS SCORM Learning Registry Solution uses a metadata semantic registry. SCORM compliant Shareable Curriculum Object can be accessed from any number of registered Web accessible databases from anywhere in the world.

After the bridging period, the eSATS metadata semantic registry will be developed by the Digital Curriculum Institute. It will provide access to digital curriculum repositories world wide[71]. It will be the K-12 digital hub for Shareable Curriculum Object knowledge, sharing, publishing, and standards. By taking any digital Shareable Curriculum Object and encasing it in a meta-data "housing" it becomes accessible and usable in any computer in the eSATS. The metadata repository will handle Shareable Curriculum Object containing text, video/voice, case studies, maps, or even subject matter experts. Low operating cost will be complemented by ease of updating the system and its registry. Quality assurance of academic effectiveness at specific proficiency levels and subjects will be maintained within the eSATS directory. Each eSATS Shareable Curriculum Object will be meta-tagged with quality ratings to support teacher or digital curriculum developer selection. The high volume Arizona use by 65,000 educators and 1,300,000 students will make the metadata registry cost effective. When operational, it could opened for use by the global K-12 market, providing significant revenues for operation of eSATS.

A Dynamic eLearning Management (DeLM) system will support the full functionality of eSATS. It must be able to assess the applicability and quality of Shareable Curriculum Object. Data security, intellectual property rights, and protection from damaging access to eSATS will require reliable identification, authentication, and authorization. DeLM will deliver valid and verified knowledge and automatic indexing and accessing of Shareable Curriculum Object, and it will support system-wide authoring and software development.

Authoring Tools: Experienced digital curriculum experts and instructional designers currently use authoring tools to create commercial grade courseware. These tools must evolve so a teacher can create eLearning experiences on the fly for her individual and small groups of students. One target could be cost-effective selection and integration of Shareable Curriculum Object using a meta-data repository and creating courseware and/or simulations on the fly.

Intelligent Computer Aided Instruction (ICAI)[34] systems are expected to become a significant part of the next generation eLearning systems. They are a good example of innovations that will emerge to shape the next ten years of K-12 eLearning adoption.

> **Cognition-Tutoring:** A foundation science of eLearning research is human cognition. Cognitive processes include perception, memory, learning, decision-making, and problem solving. The leading cognitive model for learning is tutoring. Bloom (1984) has shown that tutoring is highly effective-- over two standard deviations better than standard classroom instruction. Unfortunately, without eLearning, tutoring remains an instructional imperative and an economic impossibility.

The cognitive approach relies on intrinsic programming for the individual. This contrasts with the behavioral approach that relies on expensive and difficult-to-prepare extrinsic programming. Intrinsic programming has a simple logical sequence: display something, elicit a response, and branch to remedial or reinforcing material depending on the response.

ICAI systems have a twenty-year foundation of research and development. A meta-study of close to 300 studies of first generation types of eLearning (1975 to 1995) with conventional approaches had the following effect size results:

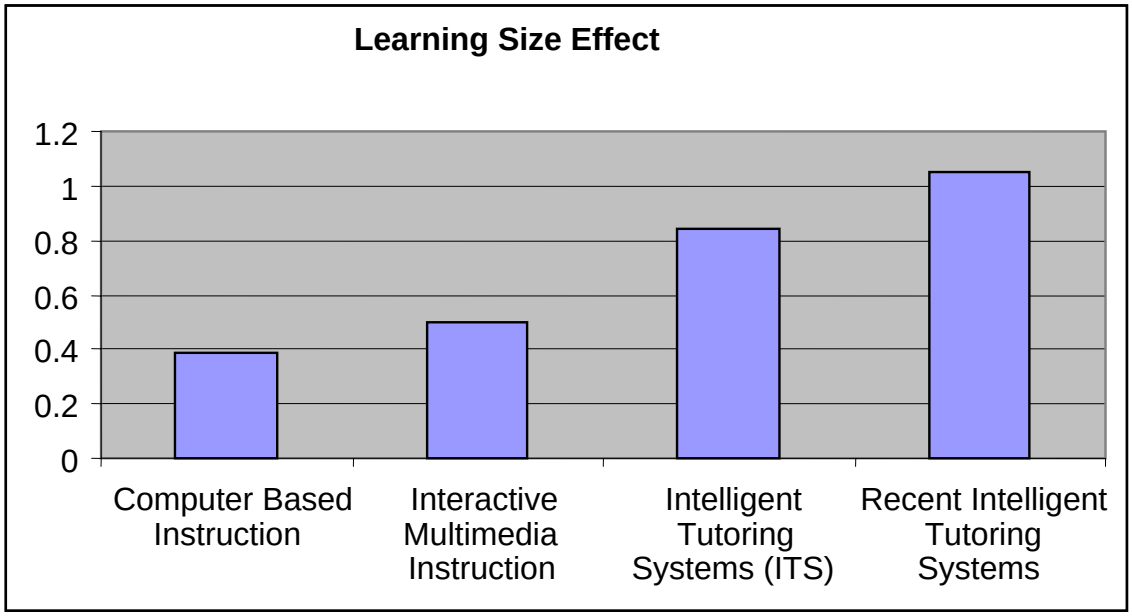


Figure 12[37]

The Shareable Curriculum Object-metadata repository and ICAI systems as envisioned above are a number of years away from common use.

The intermediate and long-range evolution of eLearning is expected to rely more and more on artificial intelligent systems. ICAI will integrate the best of past generation Computer Based Instruction and Intelligent Tutoring Systems. The five critical success factors for ICAI will be cognitive theory; assessment; collaborative, group and team learning; intelligent tutors; and human-computer interfaces. Current ICAI's can deliver one letter grade increase in learning. The future improvement of two letter grades will require significant breakthroughs, Figure 4.

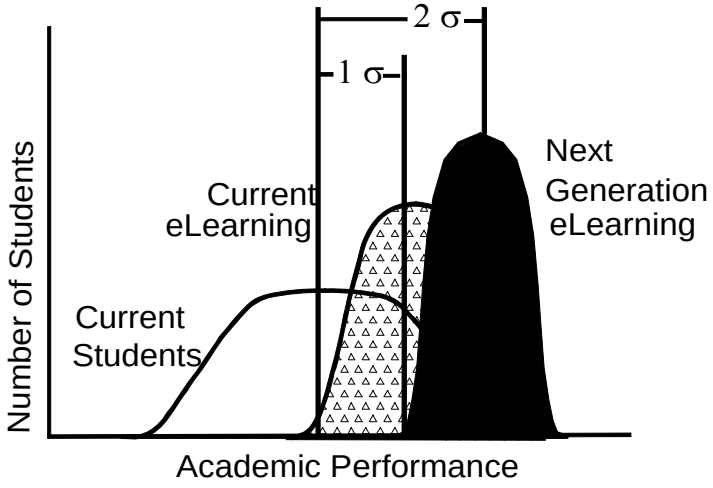


Figure 4

Computer Based Instruction is an early eLearning technology that initiated the emulation of human tutoring. The rule of thirds emerged from research in the 1970s to 1990s. Over the long run, for limited target applications, CBI costs one-third less to implement than legacy education. This total cost of ownership (TCO) associated with CBI includes research and development, initial investment, operating and support, and salvage. The performance side was just as impressive. One-third more learning takes place in a given time, or the same learning takes place in one-third less time.[33]

The next generation of ICAI is expected to play a major role in K-12 eLearning. It will have normal CBI attributes to meet the individual student needs: rate of progress, sequence of content, adjustment of content, level of difficulty, and learning style. But the "ultimate" ICAI would have two additional functions.

The first function is to have ability for student, teacher, or ICAI to ask open-ended questions and initiate instructional, "mixed-initiative" dialogue. This will require natural language integrated with the language of mathematics, mathematical logic, and other subjects.

Second, by linking to the Web with its metadata registries of Shareable Curriculum Object, the ICAI will be able to generate instructional material and interactions on demand rather than require developers to foresee and pre-store all such materials and interactions needed to meet all possible eventualities. These must be generated from information primitives using an evolved instructional grammar. Both these functionalities are being investigated with current research in learning, memory, perception, and cognition.

Research And Digital Curriculum Development

Many new eLearning technologies are currently in the laboratories: simulation; synthetic environments; virtual realty; authentic situations; intelligent interfaces with assessment and coaching; metadata standardized learning objects retrieved via semantic nets; cooperative learning systems; language interpretation; voice interfaces; multi-media;

personal authoring, and new information and data systems. eSATS is designed with the expectation that:

- research will continually enhance its digital curriculum;
- eSATS as the leading implementation of statewide K-12 eLearning will play a leadership role in K-12 digital curriculum research and development.

The world of eLearning research is fascinating and complex. To be testable, a theoretical model must be captured in an algorithm. An instructional application tests the model within its algorithm. Field testing in authentic K-12 environments is critical. From the many theory-based models only testing can prove which are effective and efficient. But K-12 eLearning has few research facilities and field testing operations. eSATS can play an R&D role in three areas.

eLearning Research Institute: Like Arizona's biotech initiative – eSATS will advocate and provide the design concept for K-12 eLearning research centers at Arizona colleges and universities. It will also promote the creation of a federally funded world-class K-12 eLearning Research Institute for digital curriculum. A preliminary design for the eLearning Research Institute has been developed for the Williams-Gateway location in east Mesa. If successful this $200 million institute would rapidly build to leadership in eLearning research.

Contract Research: eSATS also has a golden opportunity to directly position itself as a partner with the global eLearning research community. eSATS can become the facilitator for contract research that engages Arizona K-12 schools as test facilities and students-teachers as subjects. By designing the Digital Curriculum Institute with a research facilitator function, eSATS will assure rigorously controlled and professionally implemented experiments. Under contract as a profit center, Digital Curriculum Institute's a section of skilled staff will develop protocols, implement the R&D intervention, assess and analyze data, and report findings to their R&D clients. These clients will range from university and federal basic researchers to new product development operations of eLearning enterprises.

ADL K-12 CoLab: The Department of Defense established the ADL Co-Laboratory (ADL Co-Lab) in 1999 at the Institute for Defense Analyses to foster the collaborative research, development and assessment of the common tools, standards, content and guidelines for the ADL Initiative. Since then three additional United States ADL Co-Labs -- Academic (Madison, WI), Joint (Orlando, FL) and Workforce (Memphis, TN); two ADL Partnership Labs (U.K. and Canada) and two ADL Centers (ADL Technology Center and the ADL Job Performance Technology Center) have been created to form the ADL Co-Lab Network. But there is no ADL Co-Lab for K-12 education. From initial discussions with ADL management, eSATS is positioned to propose that the Digital Curriculum Institute form and host the ADL K-12 Education Co-Lab in Arizona. Goals would be:

- All global K-12 eLearning researchers will be identified, their research communities mapped, and access provided through a Web based portal. A Phase 0 contract with Office of the Secretary of Defense and the Institute for Defense Analysis has just been completed by an Arizona team who developed the design and business case for this eLearning research community portal;

- The results and products of the large body of federally funded research on K-12 eLearning will be made accessible to digital curriculum experts and teachers with the eSATS web-based metadata registry system;
- eSATS Digital Curriculum Institute will be made accessible as a professionally operated field testing facility for eLearning theories, experimental product development and certification product, and service accessibility, effectiveness, and efficiency. Access would be provided for both enterprise and public sector researchers.

eSATS leadership participated in the 1997 founding of ADL and has kept close contact with its leaders for the past decade. We believe they would welcome a proposal for a K-12 education Co-Lab.

Benefits: By being at the functional center of K-12 eLearning R&D, eSATS and Arizona schools will benefit directly from early adoption of the most effective digital curriculum. An Arizona community will develop between university researchers, eLearning enterprises, and federally funded research operations. Arizona eLearning enterprises will gain a competitive advantage from their immersion within this rich resource of eLearning research knowledge. This research mantle will support Arizona's reputation as the leading K-12 education state – the vortex center of global elearning.

Digital Curriculum Institute Design

The multiple sources of K-12 digital curriculum have poor accessibility. There is continuous change in types, access, cost, vendors, and sources of K-12 digital curriculum. Most does not have adequate testing of its effectiveness over a range of student needs. It would be difficult and costly for Arizona's 319 districts let-alone schools to individually engage the highly knowledgeable staffs required to select and install individualized K-12 digital curriculum.

The expected annual Arizona expenditures will be approximately $200 million for digital curriculum. The mission of Digital Curriculum Institute is to support this flow of cost and performance effective digital curriculum from its source to teacher-student nexus. The Digital Curriculum Institute would collaborate closely with districts, schools and class room teachers to support their decisions with factual advice.

Current sources of knowledge on and assessments of available digital curriculum are inadequate. A Digital Curriculum Institute task will be to build a knowledge database on all aspects of accessible digital curriculum. Since knowledge by itself is not sufficient, the Digital Curriculum Institute will develop extraordinary means to deliver knowledge, onsite advice, and counsel that reaches into all Arizona classrooms.

Digital Curriculum Institute will be created and operated under the auspices of the Arizona Board of Regents. The Digital Curriculum Institute will be located within Arizona's tri-university system. eSATS design includes creating a Digital Curriculum Institute modeled along the organizational lines of ASU-KAET's Arizona School Services Through Educational Technology and the Northern Arizona University Arizona K-12 Center.

Digital Curriculum Institute will be staffed with approximately 150 digital curriculum experts (1 per 7000 students). These experts will be tasked to evaluate digital curriculum offerings from all sources with application in the K-12 classroom. The evaluation shall address but not be limited to the degree to which the digital curriculum increases academic performance, supports the adopted state standards, is capability-level appropriate, is easy to use, motivates the student to learn, has transferability, and provides formative assessment data to both student and teacher. The knowledge and evaluations developed will be accessible by all school districts and charter schools through consultation with these experts as well as from Digital Curriculum Institute's website.

Digital Curriculum Institute shall provide an extension service to the classroom using instructional technologists of approximately 150 in number (1 per 300 teachers). They shall deliver counsel and on-the-job support to district digital curriculum directors and instructional technologists, and teachers in their classrooms. Each instructional technologist will be support approximately 12 schools.

Digital Curriculum Institute is expected use the services of other state agencies, individuals and organizations which have expertise in digital curriculum and operating extension services. Other states have surveyed educational software and had teachers report on its effectiveness. The Agricultural Extension Service currently under Dr. Eugene Sanders at the University of Arizona and U.S. Department of Agriculture has operated in Arizona for over a century. Evans Newton corporation in Scottsdale has national expertise in assessing the academic performance of schools and determining the need for digital curriculum. Digital Curriculum Institute will use and also influence the funding of studies such as the current testing of commercial products by the US Department of Education. Their current project includes: Early reading grade 1 – "Destination Reading" from Riverdeep Inc.; and Reading comprehension grade 4 "KnowledgeBox ®"; and Pre-algebra grade 6 "Successmaker™" from Arizona's Pearson Digital Learning.[40]

The Digital Curriculum Institute in collaboration with the Arizona Department of Education and school districts will create purchasing, hosting and support systems to optimize the cost efficiency of acquiring and using effective digital curriculum from public, commercial and open sources. Digital Curriculum Institute will reduce costs by collaboration with a number of organizations that aggregate and provide access to digital curriculum. Examples operating in Arizona include OpenVes, JesandCo, ASSET and Mohave Consortium. The actual contracts, purchases and support agreements for digital curriculum can be made at the districts, Arizona Department of Education or Digital Curriculum Institute. Training for use of the digital curriculum is addressed in Section 5. A.

Digital Curriculum Institute will assure that the digital curriculum purchased by Arizona will reside in the most cost and use effective locations. This may be on commercial or open source web sites, Shareable Curriculum Object repositories, state level Application Service Provider, district, school or classroom servers and disc drives. Some digital curriculum will be access during online learning.

Arizona Colleges of Education Research Grants

Arizona colleges have a history of K-12 eLearning research. The ASU Technology Based Learning and Research center http://tblr.ed.asu.edu/?w=793 under Gary Bitter has been rated in the top five for eLearning and instructional technology research. A state eLearning research allocation of $5 million with $1 million a year for the K-12 ADL Co-Lab and the rest for other eLearning research initiatives would garner significant additional federal research funding.

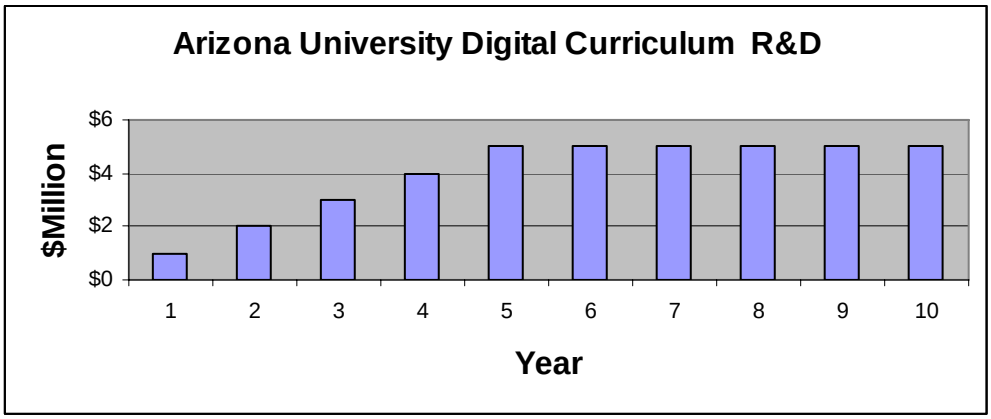


Figure 13
Arizona University Digital Curriculum Research

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Digital Curr. R&D $M	**$1**	**$2**	**$3**	**$4**	**$5**	**$5**	**$5**	**$5**	**$5**	**$5**

Table 6

Digital Curriculum Costs

Digital curriculum funding has lagged well behind with early priorities to acquire computers and connectivity. Historical costing can be reviewed but eSATS costs must be in line with needs of the eSATS design:

A mid-1990s RAND study of eight high-tech schools showed software costs averaged eight percent of technology budgets. During a McKinsey & Company, Inc. study software and online subscription fees was calculated at 14 percent of technology, but It was expected to grow in the future. During the 1999–2000 school year, Quality Education Data (QED) projected $11.47 per student on instructional software and $7.37 on Internet services across all schools $18 of digital curriculum.

As computers are brought into the classroom, each one will need an operating system, a productivity applications suite and access to subject specific digital curriculum. Periodic upgrades will address opportunities for new application versions and enhanced content.

It is difficult to forecast costs for digital curriculum. Quantity, type and source assumptions can swing the numbers by a factor of ten. As computers go from 8:1 to 1:1 at least eight times the digital curriculum will be used. At $18 now the new number might be $150 per student. This puts digital curriculum at the same level as the other three major sectors – teacher professional development, computers and connectivity and technical support.

This is probably a reasonable starting point if it is assumed that the Digital Curriculum Institute access knowledge and volume will drive unit costs down as the demand for digital curriculum soars.

In 2002 940,000 Arizona students[39] required approximately 50 full-time equivalent (FTE) technology directors, one for every 1000 teachers. These experts address the computers and connectivity and some digital curriculum. There is also a comparable number of curriculum directs in each school district. Digital Curriculum Institute will require an additional 150 digital curriculum experts and 150 field service instructional technologies.

Assuming that the total burdened cost of each staff member, including facility, management, and travel averages $70,000 per person, a fully-operational Digital Curriculum Institute for a million students would cost $21 million a year. This investment would be covered by increased cost savings in large unit buys of effective digital curriculum. Their expertise to find the effective open source or public domain digital curriculum that meets or exceeds the commercial digital curriculum.

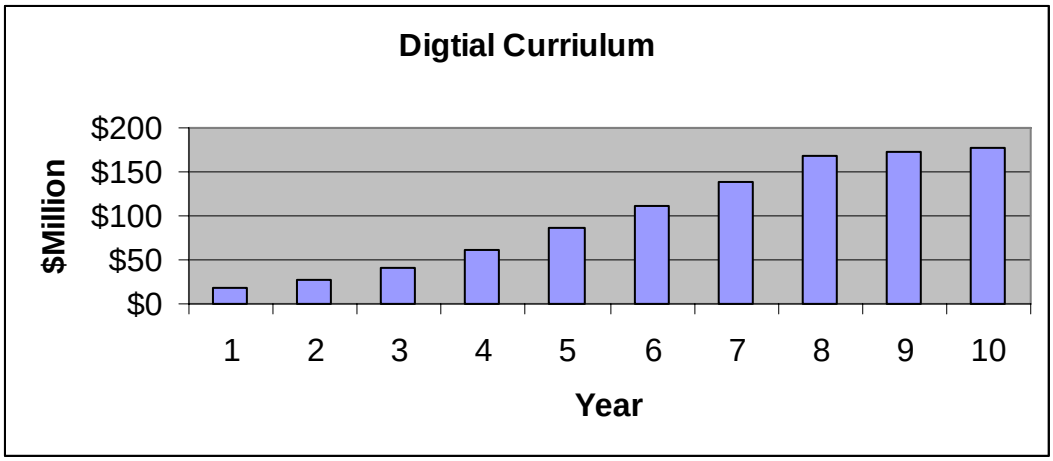


Figure 14

Digital Curriculum

CURRICULM	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Cost/Computer	$140	$140	$140	$140	$140	$140	$140	$140	$140	$140
Total $M	$19	$26	$40	$61	$87	$112	$140	$168	$173	$178
$/Student	$20	$26	$39	$57	$79	$99	$120	$139	$139	$139

Table 7

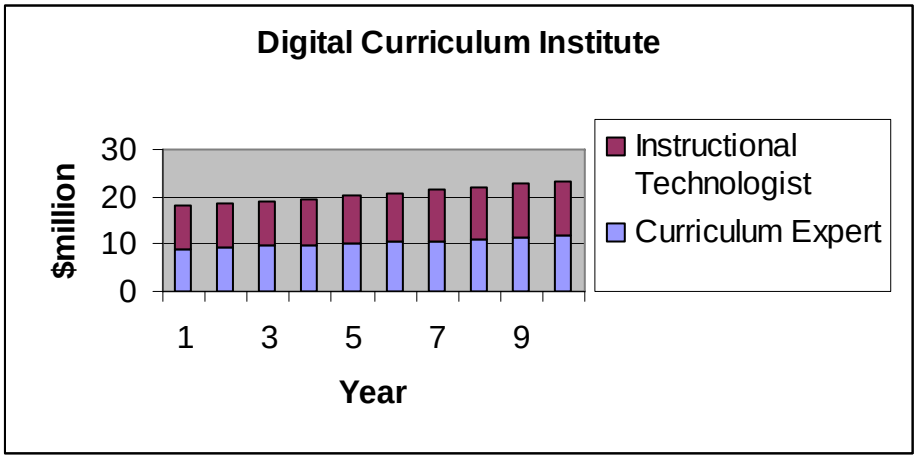


Figure 15

Digital Curriculum Institute

		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Educators/CE		400	400	400	400	400	400	400	400	400	400
Curriculum Expert		128	132	136	140	144	149	153	158	162	167
Cost/CurrInstdesn	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
Cost $M		$9	$9	$10	$10	$10	$10	$11	$11	$11	$12
Educators/CE	400	400	400	400	400	400	400	400	400	400	400
Instruc. Tecnologist		128	132	136	140	144	149	153	158	162	167
Cost/InstrDesignr	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
Cost $M		$9	$9	$10	$10	$10	$10	$11	$11	$11	$12
Total DCI $M		**$18**	**$18**	**$19**	**$20**	**$20**	**$21**	**$21**	**$22**	**$23**	**$23**

Table 8

Section 3.4 Assessment – Access – Accountability – Decision Support

A critical success factor in any operation is acquisition storage, access, analysis, reporting and use of data and information to guide performance and make assessments. There are two major K-12 education decision areas. One is at the administrative level and the second is at the learning level.

Acquired data is used for two types of assessment. Formative assessment provides immediate feedback to the administrator to manage her daily job and to the teacher and student to shape and form the learning process. Summative assessment is made at the completion of the task, course, or year. It provides a summary of financial allocations; school and teacher performance; or how much a student learns and retains over a period of time.

The teacher-student nexus is the assessment centroid of eSATS. Formative assessment is critical to mastery learning. Increased academic performance rolls up into performance improvements for teachers, schools, and the state through summative assessments. The magnitude and comprehensiveness of this task requires an enterprise solution.[62] Enterprise solutions have their foundation in a data base and implementation within a decision support system. The decision support system must support the administration but have its primary roll in managing the heart of the school enterprise – teaching and learning.

The eSATS design incorporates the current work and future success expected from the Arizona Department of Education's leadership in developing an integrated statewide data base and decision support system. Student Accountability Information System (SAIS) has been under development and use for a decade. More recently their effort to create statewide access of a data warehouse with web service for administrative needs has resulted in the Integrated Database for Enhancing Arizona's Learning[90] (IDEAL) project. Integrated Database for Enhancing Arizona's Learning addresses the teacher-student-curriculum aspects of K-12 education. Of significant challenge is to integrate all school districts with their different systems and data specification into a statewide network. A recent success has been to establish under Student Accountability Information System student identifier system. A group of leading district Chief Technology Officers is working to define and implement a single design for their district based systems that well compatible with Integrated Database for Enhancing Arizona's Learning.

A critical issue in the design and implementation of eSATS is the current lack of reliable data on major aspects of the eLearning model. Aggregated data from the classroom level on student and teacher performance and capability, technical support, educator professional development, computers and connectivity, assessment systems, and digital curriculum usage is required. The assessment – access – accountability – decision support system must also include this metadata to manage the implementation and operation of eSATS.

Administration

The data system within eSATS must support three administrative decision needs: operational, financial, and regulatory:

Operational: Human resource management of teaching staff based on capability and performance, etc;

Financial: Cost effectiveness of programs; sources of funds; allocation and use of funds; student daily attendance, and other fiduciary reporting responsibilities, etc.;

Regulatory: Pass-fail and grades for students; reporting for federal No Child Left Behind laws on highly qualified teachers and failing schools, etc.

Summative Assessment => Teacher Professional Development: No Child Left Behind law requires mandatory guidelines for teachers to be considered as Highly Qualified. Along with a bachelor's degree and state certification, they must demonstrate competency in subject matter. They can pass the AEPA Professional Knowledge Exam; hold an advanced degree in the area, be National Board Certified, or have (for middle and high schools) 24 hours of college in the content area. As an alternative, there is an evaluation Rubric where a score of 100 points establishes Highly Qualified.

Mastery learning with eSATS requires Highly Effective teachers that is assessed and measure at five levels: Entry, Adoption, Adaptation, Appropriation, and Invention. Educators are expected to advance along a continuum, increasing their capability to support student learning. Educators will be assessed upon entry and then on an annual basis to determine their eLearning proficiency level. Arizona's eLearning Education and Professional Development Institute will develop-acquire Arizona's assessment tool using the research base of the CEO Forum educator standards and International Society for Technology in Education's National Educational Technology Standards. The Highly Qualified assessment will be based on academic and experience history. The Highly Effective assessment will be based on learning performance of the teacher's students as evidenced by eLearning delivered retention and summative assessments of academic year curriculum mastery.

Educator assessment will focus on four groups. Teachers, aids, and librarians are assessed on teaching capability. Technical support and information technology directors are assessed on capability to deal with connectivity, systems software, and hardware issues. Mentor teachers, digital curriculum specialists and instructional designers are assessed on digital curriculum, content, instructional design, courseware, and professional development capability. Principals and superintendents are assessed on leadership and planning capability. Reference Appendix D.

The Arizona Department of Education Student Accountability Information System data warehouse system will store assessment data on the 50,000 K-12 educators which is expected to grow to 65,000 over the next ten years. This secured private personnel data will be used within a decision support system model. The information will be used to allocate needed professional development and support for teachers and staff, and school

districts. It will also support the Arizona Department of Education in their professional development decisions and reporting.

Formative Assessment => Teacher Professional Development: eLearning can provide a teacher performance support system.[38] This integration of on-the-job assessments and coaching with intelligent systems will result in a dynamic just-in-time decision support system for the classroom teacher. This resource will not only enhance student learning but increase teacher effectiveness as experience increases.

Arizona Department of Education and School District Summative Assessment: The Arizona Department of Education's Student Accountability Information System produces average student daily attendance data that is used to provide formula funding to school districts. It will also deliver data to the various organizations and government agencies that rank the K-12 performance of states. The No Child Left Behind regulations require that each state develop its own criteria and assess each school on whether it is failing or not. In 2003, Arizona had a 24 percent failure rate. Other states ranged from 9 to 68 percent failure. In the past two years with aggressive action by schools, districts and the Arizona Department of Education failing schools have dropped to a few dozen of the more than 1801 schools. Comparative ratings are meaningless because criteria are different for each state.

Underperforming schools are a significant concern. A school in a rich district might be performing poorly, but it is not evident because of the student population capability and home environment. A school in an economically poor or rural district might be performing with a high level of excellence but could be assessed as failing. The reasons are not school performance but because of high turnover and poor home support of the faltering students. Only complex analysis of multiple types of data will allow Arizona Department of Education to determine the truly failing schools and what is needed to bring them to success.

With Student Accountability Information System supported by and integrated into eSATS, school principals will have a system that analyzes the short-term summative assessment data. A quick response or intervention can be made if a teacher or student needs additional support or professional intervention. By making full assessments on each school, the Arizona Department of Education solution teams could be sent early in the year. This issue of "failing" under No Child Left Behind can be nipped in the bud with pinpoint applications of support. The annual "failing" assessment will become irrelevant.

The significant longitudinal capability of Student Accountability Information System [6] with Integrated Database for Enhancing Arizona's Learning will:

- Follow students from high school to college;
- Identify the relationship between early achievement levels and later student success;
- Analyze the effects of specific state policies;
- Control for student mobility in reporting school test scores;
- Improve the accuracy of socioeconomic data for high schools;
- Create fair comparisons of middle and high schools;

- Improve the investigation of promising practices;
- Provide research data on many aspects including eLearning adoption.

Student Accountability Information System would link school attendance and dropout/drop-in data, teacher capability data, and student demographic and academic performance data. If a student fails to show up for school then a search of Student Accountability Information System can be made. Dropping out or a move to a different school district can be determined, unless the student leaves the state. Rapid intervention can support the student's continuation in an effective learning environment. Valid student movement data will support studies on the best means to retain students. Reports of cyclic and year to year variations can be used for planning. Data would be available to determine a valid measure of "dropout rate."

Teacher - Student Learning

Student academic performance is strongly affected by the nature and type of formative assessment provided during the learning process. The heart of the K-12 eLearning transformation is the ability to continuously measure individual mastery of subject material. These real-time individualized digital assessments are used by the teacher and student to manage the student's learning process. This data also supports assessment of hire skills and capabilities needed to succeed in the 21st century knowledge economy. Formative assessment is closely linked with digital curriculum.

Drill and practice digital curriculum delivers minute-by-minute assessment in basic skills areas. The teacher is relieved of grading worksheets which provide next day feedback. The faltering student is freed from put-downs from both teacher and peers. Intelligent Computer Aided Instructional products include coaching with hints and adjustments in scope, sequence, and scaffolding of the learning task to the student's level of knowledge, interest and ability. Simulations deliver realistic cause-effect feedback during the learning-by-doing. This type of interactive eLearning engages students with for hours at a stretch with some attributes similar to video games. Without having to wait for assessments breaks, disengagements and distractions are minimized. The result is a more time-on-task over a normal 4- to 6-hour school day.

Freed from most administration, lecture and manual grading efforts the teacher has time for hands on use of individualized formative assessment.

Online Assessment: International Society for Technology in Education, the Consortium for School Networking, and the State Educational Technology Directors Association hosted more than 100 chief technology officers, business leaders, and stakeholders from across the country to examine eLearning's role in assessment. Classroom barriers exist, but online assessments are enabling educators to make pedagogical adjustments based on real-time analysis of student performance data. Idaho, Utah, and Virginia have online assessment programs already underway in their states. Virginia plans to deliver 100,000 online tests in 2004, 400,000 in 2005. Test scores are broken out in a variety of categories and subcategories for more accurate reporting, thus enabling teachers to better pinpoint the exact weaknesses of individual students. The test must be given on

reliable and modern multimedia computers. Both sensitive test material and personal student information must be secured.

Twelve states and the District of Columbia are administering computer-based standardized testing in 2002–2003. The motivation is to both comply with the “No Child Left Behind ” Act of 2001 and to improve data collection and analysis. The typical $10 per paper-pencil test cost is expected to be halved by using computer testing. Once the computer infrastructure is accessible for each student, a major barrier to computer-based assessment will have dropped.

Computerized testing can also be used to practice taking the real tests. Florida teachers use the Florida Comprehensive Assessment Test Explorer, a free, Web-based program that provides a series of test prompts and skills packages designed around the state’s academic-content standards, which guide the Florida Comprehensive Assessment Test. Its 11.5 million hits a day result in an average of 4,000 simultaneous users.

Student Summative Assessment and Grading: Standardized weekly, end of quarter and annual testing develops a summative report on each student’s performance. Testing delivered over eSATS automated assessment system will minimize the workload of both teacher and student, and provide Web access for parents. Digital data will feed regulatory and operational reports for both ad hoc and periodic administrative needs. The tests that make up Arizona’s Instrument to Measure Standards (AIMS) are a critical component of this set of examinations.

During the past seven years, Arizona has established academic, talent, and skills standards. These standards and the AIMS tests which are based on part of this standard set continue to be enhanced and extended to serve Arizona students. The current AIMS tests are designed to assure that students graduating high school can function in a society that requires basic reading, writing, and mathematics in English. They do not address the set of higher-level skills required to become knowledge professionals or successful in higher education within the 21st Century knowledge economy.

Standards by Area:

- The Arts
- Comprehensive Health/Physical Education
- Foreign and Native Language
- Language Arts
- Reading Standard Articulated by Grade Level
- Mathematics
- Mathematics Standard Articulated by Grade Level
- Science
- Social Studies
- Technology
- Workplace Skills

Standardized tests include the Stanford 9 and AIMS. The Stanford 9 is given to grades 2 to 9 between March 15th and May 1st. AIMS is given to Grades 3, 5, 8, and 10 from April 19 to April 30. Grades 4, 6, and 7 are in field test. If a student does not “meet or exceed

the standards" in the 10th-grade test, they prepare and retake the test in the 11th and 12th grades. AIMS tests currently cover reading, writing, and mathematics. The other standards areas are expected to be addressed with testing in the future.

Student and System Assessments: Research based on this multi-layered data will form the foundation for continuous study by Arizona's digital curriculum experts and policy institutes such as the Center for Arizona's Future and ASU's Education Policy Studies Laboratory. Typical academic performance data will include:

- major public education financial;
- early childhood education and care;
- English language learners;
- special education for disabilities;
- minority access and participation;
- teacher quality; school administration;
- teacher effectiveness;
- teacher cadre dynamics;
- school accountability;
- student learning to mastery;
- choice;
- school funding;
- eLearning adoption;
- eLearning effectiveness;
- cost savings and cost avoidance because of eLearning adoption;
- teacher professional development;
- student environment;
- parents, business, educational and social agency support;
- longitudinal postsecondary success.

The effectiveness of eSATS digital curriculum adoption from full system to classroom adoption will be assessed. Redesign decisions that drive the continuous evolution of eSATS will rely heavily on this performance data assessment.

The eSATS is designed to provide field environments and subjects for testing new eLearning theories, products, and services. eSATS assessment system will do double duty and provide test data to support the eSATS testing protocols. By providing professional grade testing and data analysis, researchers will be able to develop valid enhancements to eLearning pedagogy. Enterprises will be able to offer products proven effective by valid field research in their target market's environment.

Cost

Arizona Department of Education shall accelerate the development and deployment of the Student Accountability and Information Systems - Integrated Database for Enhancing Arizona's Learning with its data warehouse and web services aspect to assure full operation by the beginning of school year 2008-2009. Adequate support shall be provided to school districts to assure their data collection, data bases, input, analysis and reporting

is interoperable with Student Accountability Information System and Integrated Database for Enhancing Arizona's Learning, and their people are fully trained in its use.

The current Arizona Department of Education cost estimate[90] for Student Accountability Information System - Integrated Database for Enhancing Arizona's Learning proof of concept over the next three years is $5 million. IBM studied[89] ten states that are building similar systems. For a centralized model (5 states) the cost was $76 per student. For a decentralized model (5 states) the state cost was $30 per student with the districts picking a bigger piece of the bill. These systems only addressed school functionality and state reporting without portal access or teacher credentialing. The IBM design for New Mexico (322,000 students) had decentralized state reporting, data warehousing, portal and teacher credentialing, with a four year implementation. The cost was $10 to $15 million (over 4 years) without software license, hardware or hosting, network infrastructure or district Student Information System. This comes out to average $40 per student per year to build and less to operate.

The Student Accountability and Information Systems - Integrated Database for Enhancing Arizona's Learning design has higher capability and three times the students than the proposed New Mexico system. eSATS design requirement includes additional data types and access such as student formative assessments. eSATS also supports the district and school installations and ongoing training for all educators on its effective use.

The more comprehensive Arizona data-analysis-decision support system would be more costly to build than the New Mexico system, but Arizona already has a head start. The cost estimate is 1.5 times as much per student as the New Mexico system to build the Arizona system over three years at $60 million. Also assume 20% of the annual build cost will maintain and operated the system at $6 per student per year.

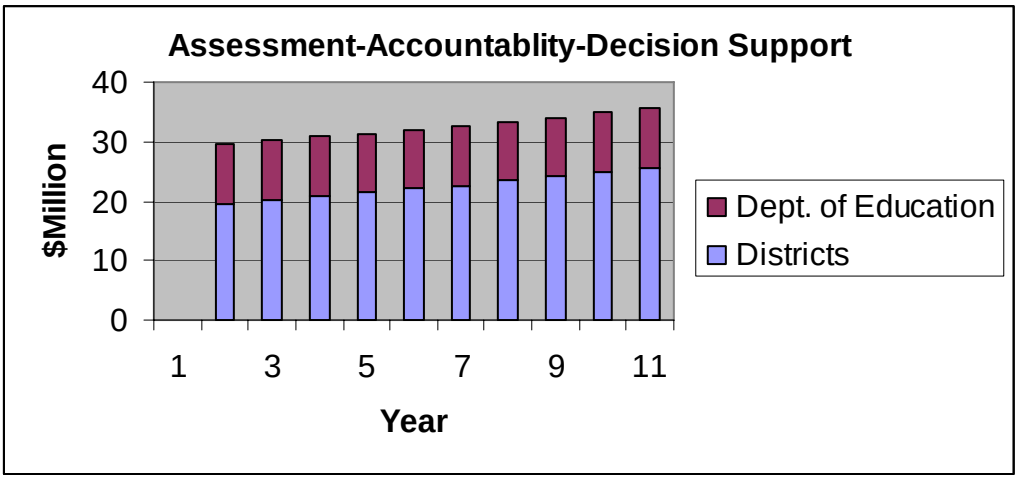


Figure 16

ASSESSMENT											
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
$ per Student		$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
Districts		$20	$20	$21	$21	$22	$23	$23	$24	$25	$26
Dept. of Education		$10	$10	$10	$10	$10	$10	$10	$10	$10	$10
Total $M		**$30**	**$30**	**$31**	**$31**	**$32**	**$33**	**$33**	**$34**	**$35**	**$36**
$/Student		$30	$30	$30	$29	$29	$29	$29	$28	$28	$28

Table 9

Section 3.5 Computers and Connectivity

Vision: By 2010 the eSATS computer-connectivity infrastructure will deliver a minimum of one student – one computer interface access for all Arizona students. By using the most efficient and effective current technology the wired, wireless and satellite system connectivity system will provide internet and digital curriculum access to multimedia student computers which are never more than five years old. This interconnecting global, state, district, school and classroom system has the capability to also support K-12 eLearning in the community and the home.

Definitions

Computer is defined within eSATS as the hardware device that provides the interface between the student and digital curriculum. Computing 1:1 means that each student has immediate access to an individually controlled display that delivers visual, audio and possibly haptic (tactile) communication to the student. The visual display may be a tiny cell phone screen, standard compute monitor, a projection on a wall screen or a virtual reality head set. The computer will also provide video, typing-text and/or pen, and microphone input to interact with the eLearning digital curriculum. The computer unit definition implies peripherals include printers, data sensors, scanners, and audio/video components.

Connectivity is the mobile to desktop to global; wired, wireless and satellite system that includes its own unique data and telephony computers, routing and storage devices to interconnect computers and to connect them to the Internet and audio-video sources of eLearning digital curriculum. The most prevalent solutions are local area networks within schools connect to district wide area network. The district then connects to global networks and the Internet “cloud” with multiple means.

Data Storage is the data and information storage devices that store and deliver digital curriculum over the connectivity systems to the teacher and student computers. Data storage devices are in classroom, school-district, state and global locations. They may function as CD-ROMS, DVDs, disk drives, file servers, caches or data warehouse server farms. Web sites and portals with functions such as application service providers are part of the data storage definition.

History

Computers: Five years ago there was approximately a 16:1 ratio of students to antiquated Apple II’s, Macintosh’s and Intel-Windows 486/586 computers. There was the same ratio of 16:1 modern multimedia computers. In the late 1990s, the School Facilities Board was tasked to bring computing up to a 8:1 ratio of modern multimedia networked computers.

In 2001, 36,000 new multimedia computers were provided by the School Facilities Board for a cost of $44 million. These were either Pentium III 600 MHz with Windows 98, NT or 2000, or Apple 350 with OS9. The RAM was 64 MB with 20X CD-ROM drives. By combining these with the approximately 65,000 modern multimedia computers already in

districts, the 8:1 ratio was met. Over half of these computers were installed in compute labs, not in classrooms.

Computers, file servers, and peripherals are expected to have a life cycle of between three and five years. With the older 65,000 computers having ended their life cycle and the 36,000 2001 purchases nearing the end of their life cycle, districts are faced replacement, moving computer assets into the classroom and increasing the ratio toward 1:1.

Connectivity: Most districts had at least partial school and district local area network solutions prior to the installation of the current systems by the School Facilities Board. In the late 1990s, the School Facilities Board was tasked to install and maintain wiring to assure that all school classrooms and districts had high-speed connectivity.

In February 2001, the School Facilities Board awarded a $100 million contract (since increased to $140 million) to Qwest Communications as the prime contractor for cabling and infrastructure. Cisco provided switchers and routers for the 100 MB (expandable to 1 GB) system. All schools operate with a Local Area Network (LAN) and connect to their district Wide Area Network (WAN). The district WAN has or will have high-speed GB connectivity to the Internet. Each classroom computer has 10/100 MB service. Cache engines provide improved speed and access to material over both the Internet and district WAN. Filtering and firewalls were provided. However, on-site maintenance and monitoring were eliminated from the contract due to budget constraints. Build out was completed in summer of 2003.

High-speed connections to the global Internet remained the responsibility of the school district. Many districts, especially those in rural locations, do not yet have high-speed access to the Internet.

The wiring, racks, and electrical closets are presumed to have a life cycle of about 20 years but their capacity may not address future needs.

Data Storage: Under the School Facilities Board Cisco provided caches and server systems for the schools. School Facilities Board also created an application service provider accessible by every public school district. In August 2001, the School Facilities Board awarded a $27.9 million contract to Cox Business Services to provide Application Service Provider services to 120 districts with 1,270 schools. The cost is $8.16 per student per year—much less than the price of one book. The Cox Education Network has been developed and deployed on their Application Service Provider. The project manager for the Application Service Provider was BearingPoint (formerly KPMG), one of the world’s largest consulting companies. Major subcontractors were LearningStation for digital curriculum and Ensynch for building and operating the application service provider and data storage system. The Cox Education Network had a 17 percent school adoption rate. The Cox contract expired in June of 2005.

Future – Emerging Technological Innovation

Computers: The number of types eLearning interfaces are growing. There will be cost effective and accessible options to the current reliance on the traditional desktop computer monitor. The student could be using a personal learning associate. His artificial intelligence based personal learning associate would deliver eLearning tailored to his needs, capabilities, motivation and learning state. This wireless, portable device could be engineered as a wearable item.

eLearning applications will require maximum computing power to support sophisticated learning in rich graphs, animation, simulation, synthetic environments, virtual reality, video, and artificial intelligent systems. The graphics engine will be similar to what is used for CDROM games and high end audio/video input and output. As new technology emerges, like the 64 bit chip the early adopters will be K-12 education.

Connectivity: The multi-gigabit per second (GB) Internet2 will emerge from the 200 university-government partnership for commercial use within the next decade.[70] Thirty-two state education networks are connected to the "Abilene" ten GB backbone. Ten thousand high school students are taking early advantage of virtual laboratories, digital libraries, distance-education facilities, and tele-immersion projects. Real time highest quality video and stereo sound can be sent over the networks high speed capacity for advanced music classes. At the college level chemistry student interaction with MediaVision Courseware over Internet2 improved their grades. Another use is shared use and control of an electron microscope. Arizona's current 100 MB district-school-classroom network system is capable of one GB but may require upgrading for the Internet2 applications.

GARDNER Group Hype Cycle

Data Storage: The cost of data storage will continue to fall as speed of access increases. As web service and data warehouse capacity proliferates the huge increase in digital curriculum storage needs for digital audio-video, 3-D animation, simulation and virtual reality will be readily served.

Current Situation

After twenty-five years of K-12 eLearning adoption, the eSATS design team estimates that Arizona K-12 education has finally reached the 15 percent level of eLearning effective connectivity and computers. The current ratio of student to modern multimedia computer interface is momentarily reached 8:1 but as the computers age, this ratio will increase. The intra-district high-speed connectivity is adequate for a number of years, but isolated rural districts need access as soon as possible. The stage is set for stepping off on a significant growth.

K-12 eLearning is a more demanding of computing systems than typical office applications. An office worker may access her organization database, the Internet, email and word processing and maybe a spread sheet. eLearning combines all the office type applications within its learning management system plus the host of data intensive instructional and assessment applications.

Computers: In 2004, the School Facilities Board's computers have entered the replacement zone. Many of the original 101,000 computers are in need of replacement while all will need replacing by 2008.

The primary focus of Students First legislation was to rectify equipment deficiencies and bring schools up to standards. These upgrades have been completed. It is now the school districts' obligation to replace and upgrade computers as they become outmoded every three to five years. Most districts are working to solve the problem, but are working toward 4:1 computing is very difficult. A small number of pioneering districts such as Vail and Wilson have 1:1 computing.

Connectivity: Now that "wiring schools" is complete the focus has shifted to building effective eLearning systems within classrooms.[42] High bandwidth connectivity through (either wired or wireless) school and district networks have the file servers-caches-routers-hubs that can be linked to high-speed Internet access. But there are many rural and low economic districts that do not yet have classroom access to high-speed Internet.

Data Storage:
Most districts have client-server systems where the file server store significant district data. The Arizona Application Service Provider takes this a step further with servers outside of the district.

Ensynch is the Managed Service Provider responsible to LearningStation for operating the Arizona Application Service Provider's data center located in Tempe, Arizona. The Application Service Provider is a good approach for rapidly delivering eLearning over a large geographic area with minimum upfront costs and support by a highly qualified technical staff. Their Application Service Provider system can easily handle the 1,000,000 email accounts necessary for all students and school staff in Arizona, although only part of the email addresses are currently in active use. The Application Service Provider hosts school and teacher websites. All students are provided a 10 Megabyte "electronic backpack" for storage of learning materials and work products. Application Service Provider resources are accessible via Internet by students, teachers, and parents from school or home, anytime. When launched this Application Service Provider system was the largest in the world. The current storage is 9 Terabytes (9,000 gigabytes). The 100 redundant servers and multiple tier one bandwidth providers deliver the very high system reliability required by this remote real time provisioning of digital curriculum. The Ensynch hosted application server provider and data system has an uncertain future because of the sunset of School Facilities Board funding in June of 2005.

The Arizona Department of Education is developing a data warehouse system to support Student Accountability and Information Systems and Integrated Database for Enhancing Arizona's Learning data needs.

Specification

Computers: The student to computer ratio need will vary depending on the phase and type of eLearning transformation. What does not vary is the need for immediate student access to a computer interface when needed. The most successful schools had the lowest student to computer ratios with highest access.

Many studies including the West Virginia Basic Skills program showed best results when the modern multimedia computers were in the classroom, not a computer lab. Studies have focused on the narrow applications of computers and connectivity such as notebooks[41]. Success has been reported with at-risk and low-achieving students and raising of English scores by 30%. Studies range from 5:1 student to computer ratio for collaborative group work to 1:1 ratio for individual work. Ongoing research by UCLA and others is developing collaborative eLearning systems where each student interfaces a computer from any location. The number of computers must lead, if only slightly, the classroom transformation from legacy education to eLearning. For basic skill drill and practice, the CBI tutoring can start out at a higher ratio, such as 4:1, as the student groups take turns. Singapore targeted a 2:1 student to computer ratio by 2002. But if the higher skills of better writers, researchers, and problem solvers are the goal, then 1:1 access is the formula.

The full adoption of modern multimedia computers in the classroom is a necessary condition for eager acceptance and participation by teachers and effective, accessible and efficient eLearning for the student. Modern multimedia computer interfaces include desktop, notebook, hand held (palm top), and network-based computers (thin clients) are current options. Limited funds have force some districts to a network computer solution. A CoSN/NSBA survey showed that a third of the districts installed a “thin-client” solution in at least some parts of their districts. Thin-client architecture has the computing and application software on a central server. Thin clients provide only an interface for student in the classroom. With central dependency for classroom operations, the network must be up 99% of the time. Some multimedia-intensive applications are not well suited for this lower-cost solution because of bandwidth restrictions. Only desktop and notebook computers have the capability to fully engage the student in a multimedia world from music to simulations which delivers maximum student retention.

Every corporate information worker expects and needs a computer. Every K-12 student is an information worker. Students are working at one of the most complex and demanding knowledge jobs—learning. They too, need their own computers. The goal is unconstrained access by every student to appropriate eLearning computer interfaces with supporting peripheral equipment. eSATS will provide desktop and notebook computers in the classroom, with palmtop and network computers used only for specialized applications. For the early years each school that selects to be an eLearning Centered School will be brought up to 1:1 computing within two years. The remaining schools will use their local and federal funds to replace and upgrade outmoded computers and systems. As the transformation is complete all schools will have 1:1 computers by the 8th year of the launch of eSATS.

Students are expected to learn within an eLearning system that links the home, community and classroom. Research shows that students with computers and Internet

access at home have higher academic performance than students that do not. The Indiana Buddy project provided home computers and modem Internet access. Compared to their non-project peers, the project students showed better writing, math, computer, and problem solving skills, along with higher self-esteem and confidence. As computer interfaces in the home become as pervasive as telephones (97%) this network becomes viable. But today's technology also has a dark side. Assure there is a computer in every student's home, but also assure that the TV is out of the student's bedroom.[87] The eSATS design addresses the costs of school based computers and expects that the family and community will support home computers. The $100 low cost school computer salvage program will be a significant factor in achieving this goal. eSATS will achieve a computer in every student's home by the end of 10 years.

Teachers with computers at home practice the use of eLearning and become more comfortable with it. Many districts or the teachers themselves have provided desktop or notebook computers for the teacher's desk. Paradise Valley and other school districts have assured the each teacher has a notebook computer with an essential suite of software and projector system for her classroom.

During the bridging phase of eSATS implementation every Arizona educator will be assured to have a modern multimedia notebook computer or other type of effective school-classroom-place of residence linked computing system. This computing system shall be loaded with a suite of essential administrative, connectivity, data entry, subject matter specific, professional development and productivity software. It shall also include a classroom projector if needed; and high-speed connectivity at both school and place of residence. Through research and expertise the Arizona colleges of education shall support the specification, design and development of the suite of essential software with collaboration of leading school districts and eLearning enterprises with experience in this field.

Connectivity: High-speed connectivity in the classroom is a necessary condition for eLearning. The lack of classroom Internet access has been a significant barrier to basic skill and higher-level education. This connectivity must be provided by a network that links classrooms within schools to districts and then to the global resources available on the Internet. There may also be some specific requirements for analog voice and video connectivity. The video-audio linkage may be broadcast or two way links between classrooms.

The two-way digital data high-speed connectivity serves five major needs:

- Student digital curriculum and content access across the entire range of eLearning and assessment for classroom use;
- Student access to online learning;
- Arizona Department of Education and district access for tracking and reporting student attendance, student academic performance, and teacher performance;
- Teacher and staff access for online professional development;
- Communications and eLearning support between school, home and community.

The Qwest-Cisco eLearning eLearning system of servers, routers, storage and portal services provided intra-district connectivity and minimizes telecommunications cost. But full eSATS deployment requires global Internet linkage through high-speed telecommunications to all 600+ districts. Urban districts have access to multiple sources of cost-effective high-speed Internet. But approximately 40 Arizona rural communities have yet to be connected with commercial high-speed connectivity services.

The State of Arizona, through its Government Information and Telecommunications Agency is pursuing the privatization of the State of Arizona's telecommunications services. Based on HB 2533 the statewide system will integrate voice, video, and data onto one network for all 91 state agencies at 267 locations within two years. Since private provider(s) will deliver this access to many remote locations, most rural school districts are expecting to benefit from this broadband initiative.

High-speed connectivity access will be completed to all schools by 2007 start. High-speed connectivity requirements will steadily increase as eLearning adoption proceeds. The bandwidth of this access will be increased commensurate with the needs of each individual school. This need will be driven by the number of computers, the type of digital curriculum deployed, and the level of home and community access. eSATS expects that the increase in the numbers of computers from 8:1 to 1:1 and the 30% grown in student population will increases the need by a factor of ten with today's applications. Over the next ten years emerging bandwidth intensive digital curriculum and increased use of online learning is expected to increase the need for high-speed connectivity another factor of ten. A typical classroom requirement that may be 10 MB now would be expected to increase to 100 MB in five years and 1 GB in ten years.

Security: Security challenges face mission-critical school infrastructures and their vulnerability to potentially catastrophic attacks. President Bush's National Cyber Security Plan demands that networks in critical infrastructures be protected from being a launching ground for cyber attacks. Schools are caught between being security police and needing to trust their users.

CoSN launched its "Cyber Security for the Digital District," multi-year initiative in 2003. It provides educational technology leaders and policy makers with strategies and tools they can use to ensure the privacy of data and the safe operation of technology within their school systems.

Of major concern is the proliferation of mobile devices that enable faculty and students to remove hardware from the network for use off-site. Wireless networks in schools have "hot spots" and other gateways that allow intruders to breach the system. If a user computer is infected by a virus offsite then the entire system can be infected once that machine is reconnected to the system. If students can take school provide notebooks home and interface back to the school networks adequate security systems, this problem can be minimized.

eSATS requires and funds districts to have well-designed security policies that identify these risks and provide state-of-the-art protection. They must clearly communicate these responsibilities and support the users and administrators who work on the network.

Data Storage: eSATS requires adequate, accessible and secure data storage. The dispersed system will range from notebook hard drives to large centralized data centers. The access will be provided by browser, web service and data warehouse applications. Growth in storage requirements are expected to parallel the computer population and digital curriculum needs with factors similar to high-speed connectivity.

Amps: Another issue is the need in older schools additional 20-amp 100VAC circuit six empty data box drops, and six duplex outlets. With 2003 School Facilities Board initiative bringing all schools up to electrical standards, this issue should have been resolved.

Design

Computers: Desktop and notebook computers will lead the eSATS implementation. The computers will be eSATS network compatible and current state of art with maximum affordable performance, storage, RAM, and network capability. Current mid-market computers will set the purchase requirements for CPU speed, disc storage, CD-ROM speed, cache, RAM, display, video board and operating system. Central processing unit and system software will have a life cycle of three to five years. Movement of the newest computers from computer lab to classroom will be complete in two years. Classroom peripheral as need such as laser printers, digital video and still cameras, and scanners will be provided. Unique needs such as data sensors for science and machine tool controls for shop will also be provided.

In the “good old days,” old computers are better than no computers.” As the focus shifts from computer labs to eLearning, this imperative shifts to “modern multimedia computers are essential.” If refurbished computers at a performance-systems level of two year old computers are available from such organizations like STRUT they can be accepted.

eSATS will be providing new computers and computer upgrades at a rate that will eventually rotate 250,000 three- to five-year-old and out dated upgraded computers out of the districts each year. This creates a reverse opportunity for the districts to provide low cost or free used computers to their communities. A statewide operation would process 1000 per day. The fully operational computers be sold at salvage cost for $100. Seventy percent of homes with K-12 students have computers but many need replacing. The homes of disadvantaged student families and retired families, small businesses and community organizations could become a market for these computers. The salvage revenues would partially offset the cost for new acquisitions. The value of 97% of students home access to networked computers even on dialup would be significant.

Connectivity

The high-speed connectivity system shall provide networking and communications capability with digital curriculum transport and eLearning implementation for all Arizona schools and their home communities. This system shall provide access to statewide and global resources. Instruction delivery shall include both student education, and teacher and administrative staff education and professional development. This open system shall be used by Digital Curriculum Institute, EEPDI, digital curriculum providers, education and professional development providers and researchers to serve their student, teacher, and administrative staff clients.

Arizona Department of Education will collaborate with the **Government Information and Telecommunications Agency** to evaluate statewide K-12 eLearning high-speed connectivity. Based on this evaluation and prospects of emerging technology the current connectivity and portal system shall be redesigned and a ten year enhancement plan implemented. They will assure that all school districts shall attain equity of access to eLearning thru cost effective broadband connectivity by the 2007 – 2008 school year. **Arizona Department of Education** shall assure that Arizona districts receive their share of federal funding for broadband connectivity including but not limited to e-rate sources.

eSATS will assure completed build out and continuous upgrade of school LAN's, district WAN's, State of Arizona network and district high-speed Internet connectivity. Typical current maximum high-speed connectivity assumed to be 10 MB at desktop, 100 MB in classroom, 1 GB in school, and 10 GB in district. This numbers will increase by a factor of 100 in ten years, but the cost is expected to remain at the same level.

Data Storage: Arizona's State level supporting data system will be a system that includes the Arizona Department of Education data warehouse and a reevaluated and upgraded version of the current Ensynch data system.

Cost

An eLearning investment leader is Singapore with 500,000 students. During the late 1990's they planned $1.2 billion to bring their computer ratio to 2:1 ratio[14,15]. At $300 per student per year they had only reached approximately 4:1 by 2003.[91] To reach 1:1 with limited resources requires long range persistent investment, when modernizing must be done on a 4 to 5 year cycle.

Arizona funding for ongoing telecommunications costs has been supported by the excess utilities provision in the school funding formula. This provision is being phased out over the next few years, forcing school districts to fund these expenses from their regular operation budget. eSATS funding .

Student growth rate is assumed to be approximately 3.0 percent a year. Assumptions include a 10 percent computer replacement after year three from purchase, 20 percent of remaining by year four and 100 percent of remaining by year five. New computers are purchased at a rate to decrease the computer-student ratio from the current 8.9:1 in 2005 to 1:1 in 2013. At four years out, it is assumed that the 2.5:1 ratio is achieved. The "unit computer cost" also includes cost of peripherals, high-speed connectivity, and the redesigned data storage system.

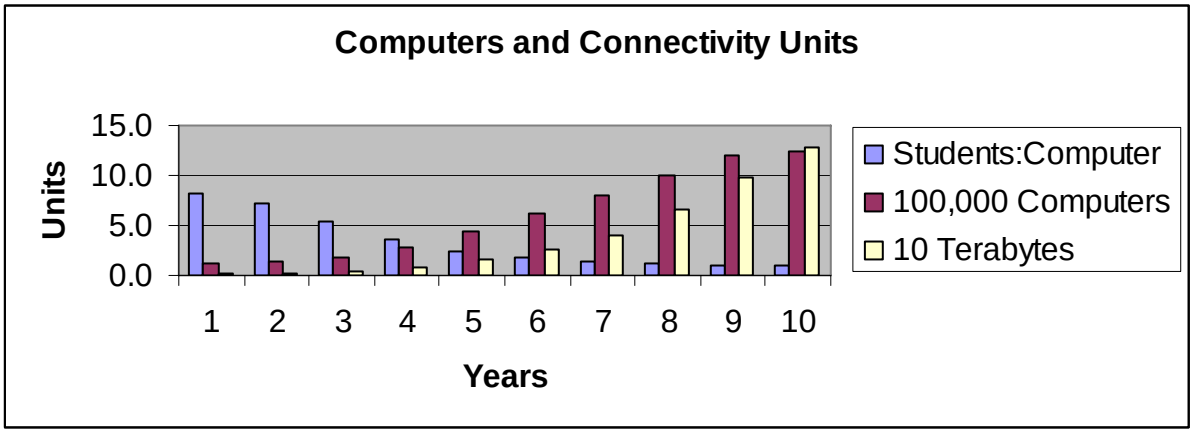


Figure 17

Students:Computer	8.3	7.2	5.3	3.6	2.5	1.8	1.4	1.2	1.0	1.0
100,000 Computers	1.2	1.4	1.9	2.9	4.3	6.2	8.0	10.0	12.0	12.3
10 Terabytes	0.1	0.2	0.4	0.8	1.6	2.6	4.0	6.6	9.9	12.7

Table 10

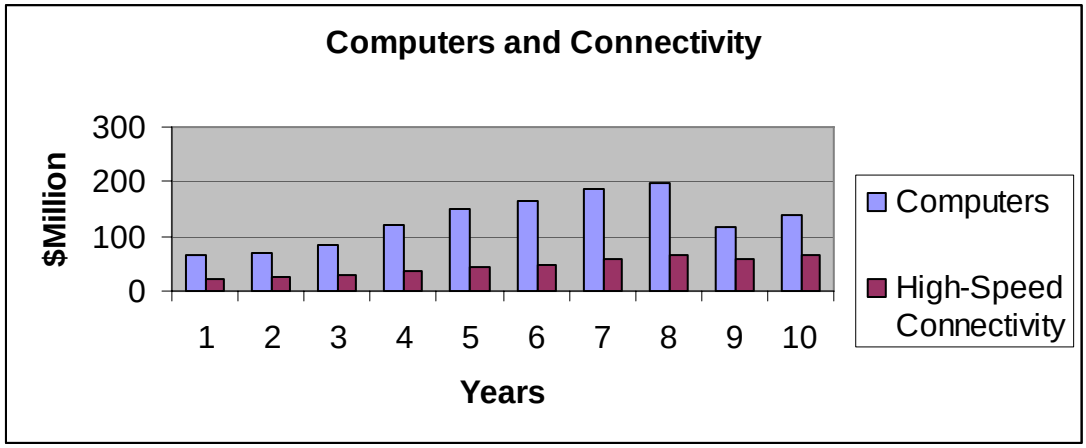


Figure 18

COMPUTERS – CONNECTIVITY				Inflation							
eSATS Analysis	04/05	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Replaced											
3 year computer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
4 year computers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
5 year computers	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Summer Changes											
New Computers	10000	80050	85969	102395	158425	235373	254433	286787	312288	203640	265890
1 year computer	10000	10000	80050	85969	102395	158425	235373	254433	286787	312288	203640
2 year computers	10000	10000	10000	80050	85969	102395	158425	235373	254433	286787	312288
3 year computers	40000	9000	9000	9000	72045	77372	92156	142582	211836	228989	258108
4 year computers	20000	32000	7200	7200	7200	57636	61898	73724	114066	169469	183192
5 year computers	30000	0	0	0	0	0	0	0	0	0	0

Modern Computers	120000	141050	192219	284615	426034	631202	802284	992900	1179409	1201173	1223118
Students	1007575	1029167	1050759	1071989	1093399	1114992	1136402	1158176	1179950	1201723	1223678
Incr. Stud. Rate	2.2%	2.1%	2.1%	2.0%	2.0%	2.0%	1.9%	1.9%	1.9%	1.8%	1.8%
Per MM Computer	8.396	7.296	5.466	3.766	2.566	1.766	1.416	1.166	1.000	1.000	1.000
Ratio Decrease		1.100	1.830	1.700	1.200	0.800	0.350	0.250	0.166	0.000	0.000
Cost $/Computer Interface+Periferals											
Unit $ + Connectivity		900	850	800	750	700	680	660	640	620	600
Total $Million		72	73	82	119	165	173	189	200	126	160
Sold											
3 year computers		1000	1000	1000	8005	8597	10240	15842	23537	25443	28679
4 year computers		8000	1800	1800	1800	14409	15474	18431	28516	42367	45798
5 year computers		20000	32000	7200	7200	7200	57636	61898	73724	114066	169469
Total Sold		29000	34800	10000	17005	30206	83350	96171	125778	181876	243945
$/salvage comptr		200	200	180	180	160	160	140	140	120	120
Total $Million		6	7	2	3	5	13	13	18	22	29
Net Cost Comp $M		66	66	80	116	160	160	176	182	104	130
$/Student		$64	$63	$75	$106	$143	$141	$152	$154	$87	$106

Table 11

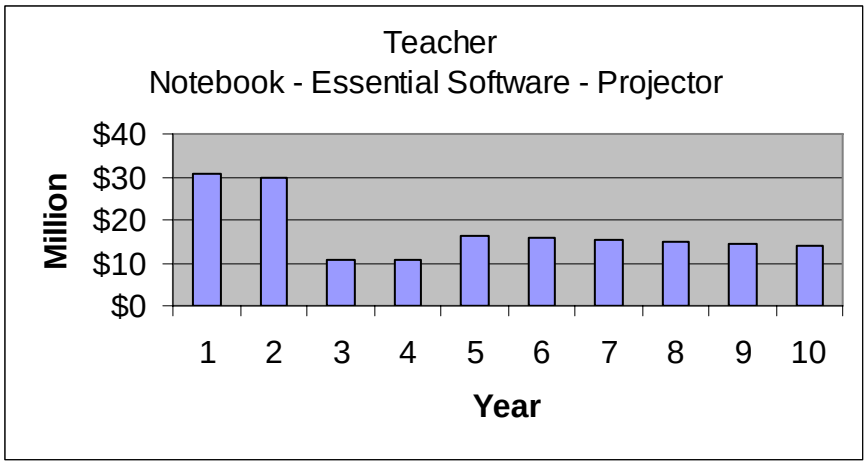


Figure 19

Teachers		51,309	52,849	54,434	56,067	57,749	59,482	61,266	63,104	64,997	66,947
% Systems		40%	40%	15%	15%	24%	24%	24%	24%	24%	24%
Systems		20,524	21,139	8,165	8,410	13,860	14,276	14,704	15,145	15,599	16,067
System Cost	94%	$1,500	$1,410	$1,325	$1,246	$1,171	$1,101	$1,035	$973	$914	$859
Tot Teacher $M		**$31**	**$30**	**$11**	**$10**	**$16**	**$16**	**$15**	**$15**	**$14**	**$14**

Table 12

Section 3.6 Technical Support

Technical support installs and maintains the computers, software systems, and connectivity. Technical support providers include workstation technicians, help-desk operators, repair people, and installers. This support must be timely and on-site so that when a failure occurs during school hours it can be fixed immediately.

The district technology director supports the planning and manages the network administration including technical support for district-wide network resources. Most of the advanced eLearning adaptor school districts have cost control strategies for their computer networks. However, only about one-third of them say they have actually adopted benchmarks or standards to measure how well they are doing.

Current Situation

Current K-12 technical support is barely adequate or in many cases inadequate. If a computer has a problem in a business environment, the problem is usually solved in a couple of hours. In schools, it is typically one to three days. Schools may use teachers, trainers, and students to provide support. This pulls them away from their real jobs. Schools have “extremely low” levels of support, usually one person for every 500 computer users. This can be compared to the 1:50 ratio in the business environment (International Data Corporation and Milken Exchange).

Models

The CEO Forum model adoption phases of K-12 eLearning require dramatic improvement for technical support:

- Early Tech: Takes several days;
- Developing Tech: Takes place next day;
- Advanced Tech: Takes place same day;
- Target Tech: Tech support available 24/7.

The operational eSATS system is expected to have at least eight times the number of modern, multimedia computing interfaces than currently exist. Computers will be multiple types and brands but interoperable on the district network. Systems will be both commercial and open source. Wired and wireless high bandwidth connectively will access a wide range of digital curriculum. Hardware-connectivity systems which were once centered in one to four computer labs will now be in a distributed system directly serving 20 to 80 classrooms.

Instruction and administration are both dependent on the system. Neither can tolerate service interrupted during the workday. Technical support requirements for K-12 education are similar to the support provided to workers in other industries like accounting and retail. If the cash register bar code pricing falters or Visa card cannot be scanned, then work grinds to a halt. A significant upgrade in quality, quantity, reliability, and response of technical support is required. The eSATS technical support must address state, district, school, and classroom needs.

Staffing

Staffing Types: (Not Teachers!) Currently forty percent of districts rely on teachers for support. But professional technical support is not the job for teachers, students, or volunteers any more than cook or janitor positions would be. Students may become involved with technical support as part of their education in the use of eLearning. As teachers move up the eLearning skill ladder, they can relieve technical support of minor issues such as rebooting computers, configuring their own software, and Application Service Provider interfaces. They will be able to provide knowledgeable information to the technicians about failure symptoms. Fairfax County, Virginia, a school district with 155,000 students and 26,000 employees, calculated the "hidden" costs of relying on teachers for support for computers. Each teacher spent at least one hour a week, which equals 330 FTE positions and a cost of $16.5 million in lost teaching time.

Staffing is by far the major cost of technical support. Medium- to large-sized districts will have a Technology Director. There is usually a network administrator who provides the hands-on management of district-wide network resources. The next level is made up of various technical support providers including workstation technicians, help-desk operators, repair people, installers, and on-site support personnel such as building technology coordinators or technology assistants.

The state level system must have technical support operation, which is integrated with the district level specialists. They, in turn, will be responsible for their individual schools. For small districts, there may be a cooperative agreement with other small districts or with a large adjacent district.

Small and rural districts, and charter schools will have unique needs compared to large districts with their caching servers, thousands of network computers, and multiple operating systems. Lack of high bandwidth land-line availability may require satellite dishes. A small school district will not be able to justify the cost of a technology director. Outside contractors from the community may be engaged at for services in any sized district.

Staffing Levels: There is a "Hodgepodge" of historical attempts to crunch the staffing numbers. The following takes us from the most expensive to the practical.

Forrester Research Inc. conducted a study in large corporations and found that typical support staff includes one support person for every 50 PCs at a cost of $1,420 per PC per year, at $70,000 per technical support person cost. (Microsoft, 1996). At 1,300,000 computers for 1:1 computing, the technical support people required would be 26,000. It is a bit difficult to visualize five man-days per year of support for each school computer or one support person per three teachers. This is definitely the upper end and not applicable to K-12 education.

MIT Project Athena[25]: A formula has been developed based on an early higher education networked system (1983–1991). Their formula is: Tech Support Staff = W/500 + U/1000 + C/15 + A/50 + L/25 + V. (W = computers; U = users; C = clusters sharing peripherals; A = software applications; L = software licenses; and V = operating systems.)

Before forcing this 15-year-old single network university formula onto the future K-12 Arizona systems, we need to make some assumptions and estimates. Let's assume 1,300,000 computers (1:1), and 1,365,000 users with teachers and staff being 8 percent of students. There are 247 locally governed districts with 1,375 schools plus 464 charter schools totals 1,839 public schools[28]. Each school is considered a cluster for technical support of peripherals. Assume an average of 25 students per 40,000 school classrooms. Assume there are 25 software applications per school. There will be 25 licenses and one network operating system per district. With the school-classroom there may be three computer operating systems (Linex, Windows, and Mac OS), but the technical support will be bundled with the computer. The results are about 4,100 technical support people—about one per every 16 professional staff, or one for every 315 students.

CoSN has studied the issue of total cost of ownership (TCO) where technical support is a significant factor. There are four major tasks: hardware installation, network and computer maintenance, software installation and upgrades, and user problems. In what one published guide to school networking considers a "fully-staffed" model, each full-time technician supports between 100 and 250 users. But the state of Maryland recently completed a four-year educational technology plan with a funding projection that assumed that there would be one support person for every 500 PCs. Denver Public Schools determined their TCO-based technical support was 1:150 for instructional computers and 1:250 for administrative computers. For every staff person trained to support networked computers, two other workers had limited technical skills.

Smart Valley was an early 1990s community networking initiative launched by Silicon Valley companies. The Smart Valley design included a school networking guide. Its analysis showed that a minimum staffing level for supporting a network was one network manager at the county level, one network manager at the district level, and a half-time network technician at each school. It envisioned that teachers, students, and volunteers would also be used, but recommended that they be used only to supplement paid, professional staff.

Discussions with Arizona technology directors in 1999 provided a school centric answer within a financially strapped situation. They assumed one technical support person was needed for every 200 computers. The current 1,055,000 computer level would require 5,250 technical support people.

Smart planning, professional installation, higher reliability, much larger number of computes and better manufacturer customer support is expected in the eSATS implementation. Well planned networked computer systems will be installed in the technology-enabled classroom. Highly standardized networks may be able to reduce the number of technical support staff. Centralized network management can also control costs by reducing travel time to individual schools. This permits some software installations, security, and back-up functions to be handled centrally. The robustness of windows and application products are improving with much less "crashing," but virus attacks are become increasingly disruptive.

Design

There is a factor of ten range from the Forrester business model to the financially strapped district model. The eSATS team decided that initially, one technical support staff will be needed for 200 computers with 8.0 modern multimedia computers per student in the classroom. We also assumed that the technical support staffing costs will decrease because of the increasing system and application reliability over the next ten years. This decrease is estimated at approximately 7 percent each year percent starting in year three. The result is to one technician for 350 computers in ten years. The design numbers of technical support staff will be a percentage of the computers, which are dependent on the students to computer ratio and student population growth.

Cost

Five years ago, the market demand for trained technology specialists was high, but the bubble burst and availability is high. Over the long haul, the pay is frequently outside the range of what schools normally pay classified staff. Training costs are expensive, due to market demand and control of "certified" training by large vendors. A five-day class on supporting Microsoft's Windows XP can cost more than $2,000. Once trained, a staff member may commands more salary in the open market. One option to providing in-house service and support is to outsource these services. Specifying, negotiating, and managing this relationship requires internal expertise. Although salaries can range from $22,000 to $75,000, for this design the estimate is an average total cost per technical staff is set at $32,000.

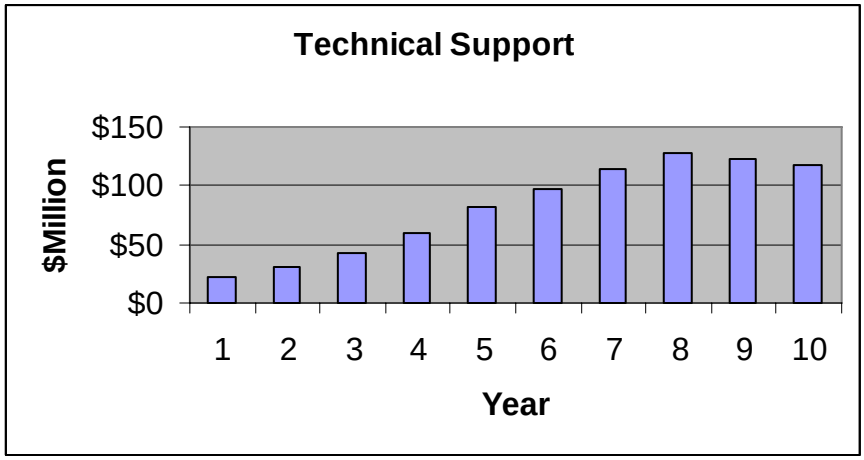


Figure 20

Technical Support

TECHNICAL SUPPORT											
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Ramp Percent		25%	50%	75%	100%	100%	100%	100%	100%	100%	100%
Computers/Tech	107%	200	200	214	229	245	262	281	300	321	344
Technicians		683	945	1336	1890	2538	3045	3557	3990	3841	3697
Cost/Tech	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
Total $M		**$22**	**$30**	**$43**	**$60**	**$81**	**$97**	**$114**	**$128**	**$123**	**$118**
$/Student		$22	$30	$41	$57	$74	$86	$97	$106	$99	$93

Table 13

The number of full-time equivalent (FTE) tech directors is estimated to be one for every 1000 teachers. Their total salary cost is $70,000 a year. This cadre of 50 technical directors will support 50 of the largest districts at a $70,000 cost per year.

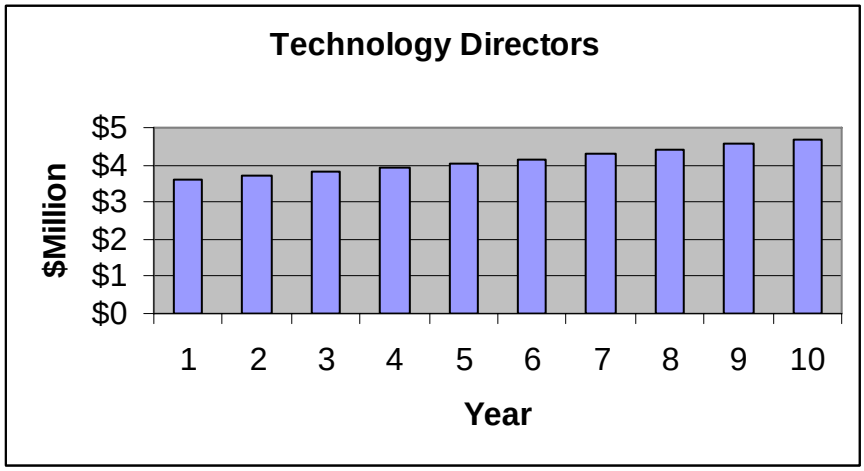


Figure 21

Technology Director	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tech Directors		51	52	53	54	55	56	57	58	59	60
Cost per	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
IT Tech Cost $M		$4	$4	$4	$4	$4	$4	$4	$4	$4	$4
Total $M		**$70**	**$70**	**$84**	**$120**	**$164**	**$164**	**$180**	**$186**	**$109**	**$134**
$/Student		$68	$66	$78	$109	$147	$144	$155	$158	$90	$110

Table 14

Section 3.7 Learning Centered Schools

Note: The word district means both school district and charter school organization.

Philosophy: The eLearning Centered School is the transformational unit selected for eSATS implementation. A transform Arizona's 2000 schools at one time makes no sense. District changes work best one school or a small group of schools at a time. The schools will self select to assure commitment to the transformation, and to entice innovation leaders first. The complete state-level eSATS implementation funding and support will be provided on a first come first basis to qualified schools. If funds are left over in any fiscal year, they will be applied statewide to the remaining schools to prepare for eLearning Centered School transformation.

Major charges are best made when all other aspects are kept the same. Buildings and facilities, personnel, classes and classrooms, and community served are expected to remain unchanged. Change will focused on eLearning teacher practice, curriculum, assessment, equipment-connectivity, and learning criteria.

Seat Time to Mastery Learning: It has been long been realized that measuring and controlling student academic performance with nine months of seat time and pass-fail of the grade level is woefully inadequate. Although convenient for large group education, and meeting seasonal activity and funding cycles of our culture, it fails to serve the individual learning needs of the student. The concept of curriculum mastery within the frame work of individualized learning plans without calendar-time constraints offers an ideal alternative. Only now with the availability of eLearning the tools and processes becoming available the means to transform K-12 education to individualized mastery learning are at hand.

There has been ten years of intense effort by the state board of education to adopt academic standards for most subjects at every grade level, and by Arizona schools to improve student academic performance to meet these standards. eLearning builds on this foundation by delivering the means to achieve mastery of subject matter. But to complete this vision the funding formulas and regulations of K-12 education must be rewritten to replace seat time with mastery of subject.

The new unit of measure will be the individual student academic year not the current calendar year. The funding and its controls will be based on the principle of masterly learning of the academic year by the individual student.

Individual academic year: Based on the current academic standards the core subjects of the current twelve grades plus kindergarten will be used as the foundation to define the academic year. Using this foundation an individual academic year will be designed for each student and be captured in the student's individual learning plan. The academic standard defined goals for each mandatory subject and target goals for each mandatory and selected subject will be specified within the individualized learning plan. Within the eLearning system the student will learn at an optimum pace and subject goals will be reached at different times. When all academic standard defined goals have been reached and the student, parent and teacher agree that an adequate level of target goals have

been reached the student will have achieved that individual academic year. At that time a new individual learning plan is created for the next individual academic year. Computerized-automated tools for plan development, assessment matching with academic standards and target goals, and overall academic year achievement will provide decision support for the student-parent-teacher team.

Graduation will require completion of all thirteen academic years. By assuring academic standards are met for each academic year, students do not fall behind and are prepared to past the final AIMS summative examination.

Funding – compliance – accounting: The department of education will provide alternative budgeting and financial assistance on a school by school basis in lieu of the budgeting and financial assistance provided pursuant to chapter 9 of title 15 of Arizona school law.

The school will be funded for the individual student at the beginning and at the midpoint of the student's academic year. The auditor general, in cooperation with the department of education, will review existing audit compliance requirements for districts to determine compatibility with the budgeting and financial requirements eSATS mastery learning procedure. The auditor general will develop new audit compliance requirements for districts and their eLearning Centered Schools. Districts that apply for participation under the alternative budgeting and financial assistance prescribed in this chapter 9.1 are not subject to chapter 9 of this title 15.

Funds Use Flexibility: The Auditor General Office, Department of Education and Arizona districts must collaborate to create a flexible funding system for all districts that supports a Total Cost of Ownership funding model. Savings in areas such as avoided construction costs, books and early graduation must be usable by the district to funding teacher salary increases and the wide range of other eLearning equipment and operating costs. Funds may be transferred across current boundaries between construction, and maintenance and operation budgets.

System -- purpose – scope -- potential: E-learning centered schools will offer students a comprehensive academic program delivered through a variety of e-learning methods and digital curriculum and individual learning plans intended to assure every student the opportunity to meet and exceed the academic standards adopted by the state board of education at every grade level. The individual learning plans will be created to assure that the student academic and motivation potential are achieved. In most cases this achievement level is expected to significantly exceed the state academic standards in most subjects.

E-learning centered schools may consist of new charter schools, existing charter schools or all or any portion of an existing school district. All e-learning centered schools remain public schools.

Specifications – criteria: An eLearning centered school must adopted a curriculum that is fully aligned with the academic standards adopted by the state board of education for each grade level. At least fifty per cent of the adopted curriculum is delivered using digital curriculum and the remainder of the curriculum is supported by e-learning tools where

appropriate. The entire curriculum is individual student paced and matched to each student's documented academic competency level as measured by formative assessments. Each classroom has the necessary e-learning equipment, connectivity and software systems to assure that every student has immediate access to appropriate digital curriculum.

The instructional staff has obtained substantial education and training in the delivery of academic curriculum using digital curriculum and formative assessment within the e-learning process. The eLearning centered school has systematic access to e-learning education and professional development, including mentoring by master-mentor teachers. The school has instituted a data based system that provides immediate access to assessment of academic progress by the student, parent, instructional staff, administration and department of education for guidance and decision support. There is an established evaluation system that provides periodic review of adopted e-learning technologies and methods, new e-learning technologies and other methods that become available in the future.

An eLearning centered school must instituted a continuous e-learning upgrade and adoption program as provided to improve the academic performance of students and to provide data to digital curriculum and eLearning equipment providers for improvement of products and services. The annually updated strategic and implementation plan addresses e-learning technology, digital curriculum and education and professional development.

The eLearning centered school organizes and continuously supports an e-learning parent and community advocacy group to facilitate the e-learning transformation in the classroom, in the homes of students and in the community.

Approval

Process: The department of education shall approve schools as e-learning centered schools based on the department of education's review of an application submitted by the school district within which the school is located or by the governing body of the charter school. The approval shall be in the form of a written agreement signed by the superintendent of public instruction and by the school district governing board or the governing body of the charter school. The agreement shall be in effect for an initial period of ten years which may be extended on written agreement of all parties to the agreement. The agreement may not be modified except on written agreement of all parties to the agreement.

B. The department of education may grant provisional approval of an e-learning centered school with an agreement to be in effect for a period not to exceed five years to a school that does not yet meet the minimum criteria prescribed in section 15-1053 if the application submitted identifies the unmet criteria and indicates the method and timeframe by which the criteria will be met.

C. The department of education may terminate approval of an e-learning centered school if the department of education, after investigation and notification of the school, determines that the school is not in compliance with this chapter or the agreement.

Application review process: The district submits an application for one or more schools to the department of education. The application will contain standard data such as the number of students and grade levels and ratio of pupils to teachers, along with data on teaching, classroom support and administrative staff. The school achievement profile including current No Child Left Behind assessments along with type and population of special programs such as gifted, special education, English language learner and AIMS remediation would be required.

The proposal will identify changes to the existing curriculum including timelines, detailed strategies, education and professional development needed and when the e-learning centered program will be fully implemented into classroom. The budget will be both operational and capital and reflect additional support by the district.

The department of education will have sixty days to review. If accepted the department of education will submit an agreement to the district that includes the specific obligations that the school will undertake based on the application and subsequent negotiations with modifications, visitations and additional documentation. It will also include the specific criteria for student academic progress.

If disapproved, the district will be sent a report with the specific reasons. Appeals can be made to the state board of education or state board for charter schools.

Funding

Budgeting: An annual estimated budget will be submit to the department of education for the per student amount of funding necessary to advance each student one full academic year plus monies from any other sources such as the district. Each student's academic progress shall be based on assessment criteria agreement. The academic year may be longer or shorter than the calendar year. The student's academic year date ends on the date that the student has mastered the learning required by the academic standards adopted by the state board of education.

The per student amount will not exceed the per student statewide average expenditure for the previous fiscal year, except that the department of education may provide for additional e-learning allowances. These allowances will be in the areas of teacher and staff professional development; mentoring; performance incentives; digital curriculum; assessment, access, and decision support; computers and connectivity; and technical support.

Budget adjustment: Districts may use the average daily membership of e-learning centered schools to calculate funding for services that the district provides to the e-learning centered school, including pupil transportation, food services, building maintenance and repair.

Time Table

From the approximately 2000 Arizona public schools some 100 to 300 are expect to select to become an eLearning Centered School with the first three years. Within two years the Auditor General Office in collaboration with the Arizona Department of

Education and Arizona school districts will have established the rules, agreements, budgeting procedures and accounting systems for eLearning Centered Schools.

Costs

There will be significant start up costs to create the new rules, regulations and audit procedures and mechanisms. Significant training at the state level with more at the district level will require addition funds over the first ten years of eSATS implementation. This funding will be used and also distributed to the school districts by the Auditor General Office.

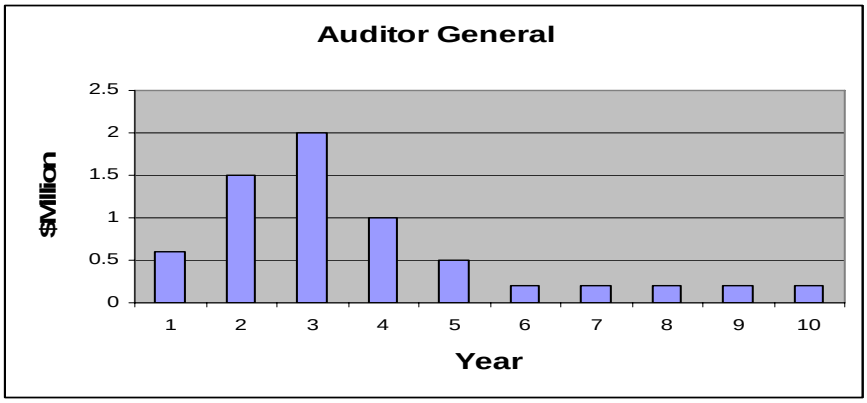


Figure 22

		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Auditor General	0	0.6	1.5	2	1	0.5	0.2	0.2	0.2	0.2	0.2

Table 15

Section 4 Ten-Year Time Line

Time: There have been many studies of transformational initiatives within large organizations. The typical time it takes for changes in culture, task processes, professional development, funding, and technology to mature is approximately eight years.

The March 2002 Arizona Department of Education Educational Technology Plan[6] had a 4 year timeline to bring eLearning from the current levels of 2001-2002 school year to full fruition in the 2004-2005 school year. There has been little material progress in the past three and a half years since the plan was not funded. Their March 2002 plan was updated in February 2004 to reflect the needs of the Federal government. It is currently being revised (summer-fall 2005) to reflect the needs of Arizona K-12 education and is intended to be implemented by the Arizona Department of Education. The eSATS design will incorporate the goals of this plan as it emerges.

The eSATS design has a built in implementation plan. The time of eight years has been chosen as the target for transformation and ten years to approach maturity. First time assumptions and forecasts were made for critical populations. Then assumptions were made on the lagging factors for human resources, institute building and funding implementation. The timing for the two phases (Bridging and Full Implementation) were then developed.

Arizona Population Growth: A significant aspect of the eSATS plan is the phenomenal grow that continues unabated in Arizona's K-12 system. The current projections from State government sources are that the 3 percent rate of student population growth over the past several years will hold for at least the next two years. Scenarios with ranges of growth rates could be run (and have) but a design must address the largest expected loads. The assumed 3% rate of growth for ten years is possible and is expected to provide a reasonable margin of safety. The eSATS population forecast used for the design assumes that the ratio of teachers to students will not change. This variation of this ratio as a function eLearning efficiency will be explored in the cost analysis section.

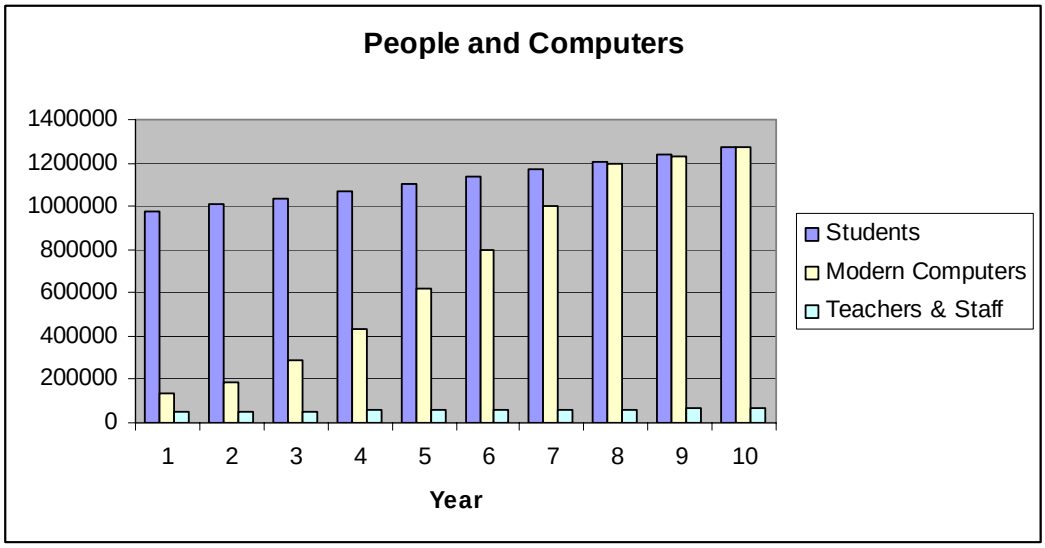


Figure 23

SUMMARY	UNITS	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Student Growth	3.10%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Students	950000	978500	1007855	1038091	1069233	1101310	1134350	1168380	1203432	1239535	1276721
Stdnt/Cmptr	8.3	7.2	5.3	3.6	2.5	1.8	1.4	1.2	1.0	1.0	1.0
Modern Computers	115000	136645	189060	285907	432736	621904	798349	997874	1197600	1233528	1270534
Teachers & Staff	49815	51309	52849	54434	56067	57749	59482	61266	63104	64997	66947
Teacher Mentors		257	528	817	1121	1155	1190	1225	1262	1300	1339
Tech Directors		51	53	54	56	58	59	61	63	65	67
Technicians		683	945	1336	1890	2538	3045	3557	3990	3841	3697
Curriculum Experts		128	132	136	140	144	149	153	158	162	167
Instructional Designers		128	132	136	140	144	149	153	158	162	167

Table 16

Lags: The legislature is assumed to follow tradition and will require four years to build up to full funding for a program of this magnitude. The first four years investment will address the bridging areas to be prepared for initial eLearning Centered School adoption in year two with full adoption rate by year four.

The State assessment system must come to full operation as soon as possible to support and tie together all the other system sections. It will take a minimum of two years from start to bring the new institutes to full operation to support teacher education and professional development, digital curriculum acquisition and student environment engagement. Building effective staffs from the small global pool of experts will take several years to become fully operational.

The high-speed connectivity build out to all un- and under- served communities must be winning up in year three to assure eLearning Centered School access.

Computers per student ratios are currently at 1:8.5 (Figure 15) will be brought to 1:1 by year eight. The lower increase at the beginning aligns with fewer funds available and the need for building up slowly with a small number of eLearning centered schools in the first

three years. Classroom computers must then be aggressively acquired for if teacher professional development or digital curriculum is not to lag. The number of technicians needed is driven by the number of computers.

A number of Arizona schools are ready to apply for eLearning Centered School status. Most are several years away from developing the external community and parent, and internal staff and leadership support necessary to make the decision.

Adequate digital curriculum is currently ready and accessible to initiate eSATS. But ten years will be needed along with Arizona's market pull and leadership prodding to acquire effective digital curriculum to meet all grade, subject, formative assessment, activity and individual student needs.

The education and training of in-service teachers is expected to take four years to bring them to full eLearning capability. Some teachers well along, but most are just starting to learn about K-12 eLearning and have implemented minor components into their practice. Online and regional education and professional development curriculum resources for in-service teachers are accessible for most current needs. A serious lag not amenable to assumption will be the development of digital teacher education and professional development curriculum at the fifth level. At the fifth level eLearning specific pedagogy is used in most content areas that address all grade, subject, assessment and individual teacher needs. The transformation of the colleges of education will take four years to transform its curriculum to graduate eLearning savvy teachers.

By the eighth year it is expected that Target Tech (Adaptation and Innovation) level of professional development will mature at eighty percent. One hundred percent will not be obtained because of turnover, changing digital curriculum and standards to be met, and unique cases not needed this level of capability. This time line will be used for the transforming the staff practice of mentor teachers, digital curriculum specialists, instructional designers, principals, and superintendents.

The following chart (figure 16) is a graphic illustration (not analytical data) on the leads and lags of the major components:

eSATS funding level
Student to Computer goal of 1:1
Arizona teacher cadre average skill level compared to Target Tech.
Schools selecting eLearning Centered School status

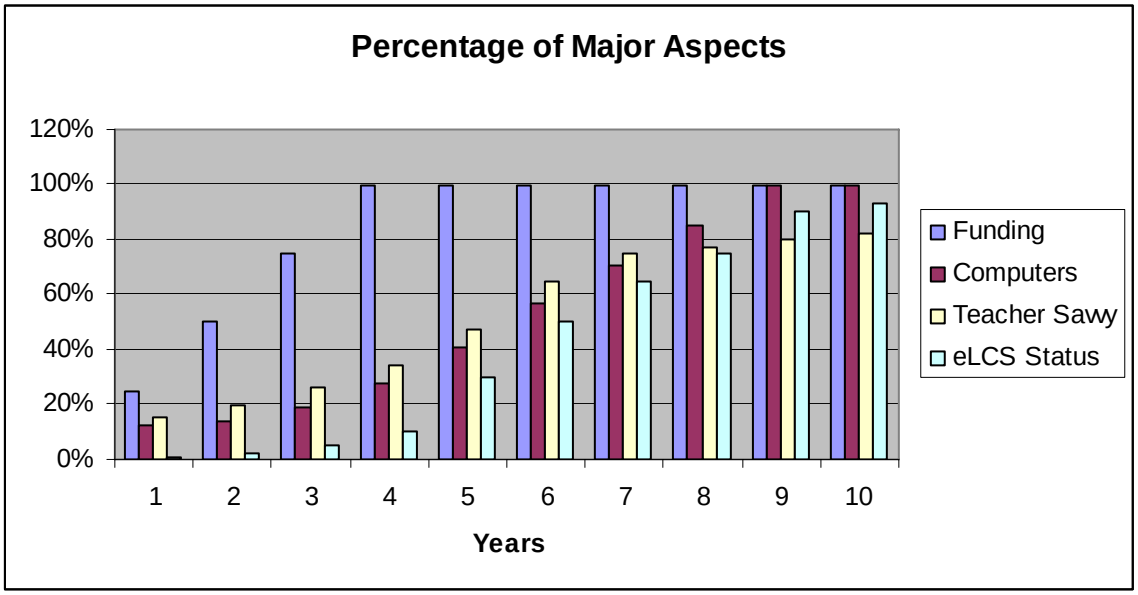

Percentage of Major Aspects
120%
100%
80%
60%
40%
20%
0%
1
2
3
4
5
6
7
8
9
10
Years
Funding
Computers
Teacher Sawy
eLCS Status

Figure 24

Section 5 Costs and Funding

Note: These calculations use constant dollar projections with zero inflation, and most values are annual.

Philosophy

Some research has shown level of school funding has little relationship to student academic performance. Other research such as a Texas A&M University study found a "significant relationship between school spending and student performance." [64] Both sets of research address comparing funding of schools using legacy education method. Neither side of this argument is meaningful when a transformation is being considered.

As legacy education is transformed to eLearning the financial analysis must address what is required to successfully complete the task. The initial costing of the eSTATS design is bottoms up, without regard to historic costs or costs for other aspects of legacy education. The assumptions included no changes in buildings, legacy staff, current curriculum or academic standards.

After the costs for eSATS was determined, then the effect of eSATS on both increase and reduction of legacy costs was made. Major effects were due to the effectiveness, efficiency and accessibility that eLearning brings to the transformed school and school district.

Funding Analysis

Teacher and Staff Professional Development: Cost for classroom or online professional development is $1,200 plus the allocated cost ($1,200) for one master teacher-mentor-coach for each fifty teachers and staff. Total is $2,400 per teacher per year.

TEACHER & STAFF	**Education & Professional Development**										
	45000	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 7**	**Yr 8**	**Yr 9**	**Yr 10**
Percent Engaged	8%	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%
Teachers & Staff	49815	51309	52849	54434	56067	57749	59482	61266	63104	64997	66947
Prof. Dev/Teacher	1200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200
Tot Prof. Dev $M		**$15**	**$32**	**$49**	**$67**	**$69**	**$71**	**$74**	**$76**	**$78**	**$80**
Mentor%	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Teacher Mentors		257	528	817	1121	1155	1190	1225	1262	1300	1339
Cost/Mentor	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Tot Mentor Cost $M		**$15**	**$32**	**$49**	**$67**	**$69**	**$71**	**$74**	**$76**	**$78**	**$80**
eTEPDI ADE		$5	$6	$7	$8	$8	$8	$8	$8	$8	$8
eTEPDI ABOR		$5	$6	$7	$8	$8	$8	$8	$8	$8	$8
Tot eTEPD Institute $M		**$10**	**$12**	**$14**	**$16**	**$16**	**$16**	**$16**	**$16**	**$16**	**$16**
Total $M		**$72**	**$105**	**$123**	**$161**	**$171**	**$174**	**$178**	**$182**	**$186**	**$190**
$/Student		$73	$104	$118	$151	$155	$154	$153	$151	$150	$149

Table 17

Current expenditures: Assume that approximately $120 per year is being spent in the districts and special state programs on professional development per teacher to total $6 million statewide. Assume there are currently 50 teachers functioning as eLearning savvy mentor teachers for a total of $3 million.

Digital Curriculum

Content, courseware, application and system software estimates from prior national studies and planning processes have shown that digital curriculum has been about 10 percent of the total cost of educational technology. The eSATS design, which is dominated by teacher professional development and digital curriculum, increases this amount to $140 per instructional computer, at about 25% of total cost.

CURRICULM											
Direct											
eSATS Analysis	04/06	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Cost/Computer	140	140	140	140	140	140	140	140	140	140	140
Total $M		**$19**	**$26**	**$40**	**$61**	**$87**	**$112**	**$140**	**$168**	**$173**	**$178**
$/Student		$20	$26	$39	$57	$79	$99	$120	$139	$139	$139
Digital Curriculum Institute											
eSATS Analysis		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Educators/CE		400	400	400	400	400	400	400	400	400	400
Curriculum Expert		128	132	136	140	144	149	153	158	162	167
Cost/CurrInstdesn	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
Cost $M		$9	$9	$10	$10	$10	$10	$11	$11	$11	$12
Educators/CE	400	400	400	400	400	400	400	400	400	400	400
Instructional Tecnologist		128	132	136	140	144	149	153	158	162	167
Cost/InstrDesignr	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
Cost $M		$9	$9	$10	$10	$10	$10	$11	$11	$11	$12
Total DCI $M		**$18**	**$18**	**$19**	**$20**	**$20**	**$21**	**$21**	**$22**	**$23**	**$23**
Research In Arizona Universities											
Ed & Prof. Dev Research		**$1**	**$2**	**$3**	**$4**	**$5**	**$5**	**$5**	**$5**	**$5**	**$5**
Total $M		**$37**	**$45**	**$59**	**$80**	**$107**	**$133**	**$161**	**$190**	**$195**	**$201**
$/Student		$38	$45	$57	$75	$97	$117	$138	$158	$158	$158

Table 18

Current costs: Digital curriculum is estimated as being acquired at $40 per current computer and the current number of computers is 125,000. The annual data is not available. There are few digital curriculum experts or instruction designs working in K-12 education which will require new-hires for the digital curriculum institute.

Computers and Connectivity

The School Facilities Board has assured a minimum of one modern multimedia computer for eight students. Many of these computers are still in computer labs separate from the classroom. The transformation to a 1:1 ratio of student to computer access over eight years will populate the classroom with a range of devices from desktop computers and notebooks. Network computers and handheld devices are useful for specific-limited application, such as lab data collection. New computer prices range from $900 to $600 as prices continue to drop and performance increases. Computer salvage value is modest with the market being mostly home and community users. The high-speed connectivity system increases to about $50 per student. Teacher computing cost is initially $30 per student that decreases to $12 per student. A small cadre of information technology directors of approximately 50 is needed at a cost of $70,000 a year.

Computers Peripherals Connectivity											
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
% remaining											
3 year computer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
4 year computers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
5 year computers	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
New Computers	10000	75645	87215	106847	163393	218706	257293	297891	327937	218668	270576
1 year computer	10000	10000	75645	87215	106847	163393	218706	257293	297891	327937	218668
2 year computers	10000	10000	10000	75645	87215	106847	163393	218706	257293	297891	327937
3 year computers	40000	9000	9000	9000	68081	78493	96162	147054	196835	231564	268102
4 year computers	20000	32000	7200	7200	7200	54465	62795	76930	117643	157468	185251
5 year computers	25000	0	0	0	0	0	0	0	0	0	0
Modern Computers	115000	136645	189060	285907	432736	621904	798349	997874	1197600	1233528	1270534
Students	950000	978500	1007855	1038091	1069233	1101310	1134350	1168380	1203432	1239535	1276721
Incr. Stud. Rate	3.1%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Per MM Computer	8.261	7.161	5.331	3.631	2.471	1.771	1.421	1.171	1.005	1.005	1.005
Ratio Decrease		1.100	1.830	1.700	1.160	0.700	0.350	0.250	0.166	0.000	0.000
	0.1211	0.1396	0.1876	0.2754	0.4047	0.5647	0.70379	0.8541	0.9952	0.9952	0.99515
Unit Cost		$900	$850	$800	$750	$700	$680	$660	$640	$620	$600
Total $Million		$68	$74	$85	$123	$153	$175	$197	$210	$136	$162
Sold											
3 year computers		1000	1000	1000	7565	8721	10685	16339	21871	25729	29789
4 year computers		8000	1800	1800	1800	13616	15699	19232	29411	39367	46313
5 year computers		20000	32000	7200	7200	7200	54465	62795	76930	117643	157468
Total Sold		29000	34800	10000	16565	29538	80848	98366	128211	182740	233570
$/salvage comptr		125	130	135	130	120	110	100	100	100	100
Total $Million		4	5	1	2	4	9	10	13	18	23

Net Cost Comp $M		64	70	84	120	150	166	187	197	117	139
$/Student		$66	$69	$81	$113	$136	$146	$160	$164	$95	$109
Connectiviity											
GITA-HighSpeed		$5	$4	$3	$2	$1					
App Svrs Portal		$10	$10	$10	$10	$10	$10	$10	$10	$10	$10
Internet/Comptr	$30	$4	$6	$9	$13	$19	$24	$30	$36	$37	$38
Infrastruct/com	$60	$5	$5	$6	$10	$13	$15	$18	$20	$13	$16
Tot Connectivity		$24	$25	$28	$35	$43	$49	$58	$66	$60	$64
Management											
Technology Director	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tech Directors		51	53	54	56	58	59	61	63	65	67
Cost per	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000
IT Tech Cost $M		$4	$4	$4	$4	$4	$4	$4	$4	$5	$5
Teacher Notebooks Essential Software Projectors											
% Teachers New		40%	40%	15%	15%	24%	24%	24%	24%	24%	24%
Systems		20,524	21,139	8,165	8,410	13,860	14,276	14,704	15,145	15,599	16,067
System Cost	94%	$1,500	$1,410	$1,325	$1,246	$1,171	$1,101	$1,035	$973	$914	$859
Tot Teacher $M		**$31**	**$30**	**$11**	**$10**	**$16**	**$16**	**$15**	**$15**	**$14**	**$14**
Total $M		**$122**	**$128**	**$127**	**$170**	**$213**	**$235**	**$264**	**$282**	**$196**	**$222**
$/Student		$125	$127	$122	$159	$193	$207	$226	$234	$158	$174

Table 19

Current costs: Estimated purchases of 20,000 computers a year at $1500 produce costs $30 million. Teacher computing costs may be at $5 million a year. Assume the current FTE information technology directors number 28 for $2 million a year.

Assessment – Access – Accountability – Decision Support

Assume that districts need to spend $10 and the State $5 per student per year to develop, renew and operate the digital assessment system.

ASSESSMENT											
eSATS Analysis		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
$ per Student		$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
Student Cost		$20	$20	$21	$21	$22	$23	$23	$24	$25	$26
State		$10	$10	$10	$10	$10	$10	$10	$10	$10	$10
Total $M		**$30**	**$30**	**$31**	**$31**	**$32**	**$33**	**$33**	**$34**	**$35**	**$36**
$/Student		$30	$30	$30	$29	$29	$29	$29	$28	$28	$28

Table 20

Current Costs: Assume that the current costs for the digital aspects of assessments are $3 per student for $3 million a year.

Technical Support: The critical assumption is that one technician can assure 99% up time for 200 computers and their connectivity/data systems. The second assumption is that through continued enhancement of maintenance productivity tools and system reliability technician time reduces by 7% per computer per year.

TECHNICAL SUPPORT											
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Computers		136645	189060	285907	432736	621904	798349	997874	1197600	1233528	1270534
Computers/Tech	107%	200	200	214	229	245	262	281	300	321	344
Technicians		683	945	1336	1890	2538	3045	3557	3990	3841	3697
Cost/Tech	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
Total $M		**$22**	**$30**	**$43**	**$60**	**$81**	**$97**	**$114**	**$128**	**$123**	**$118**
$/Student		$22	$30	$41	$57	$74	$86	$97	$106	$99	$93

Table 21

Current Costs: Assume that there are currently 440 technicians employed by the districts at $14 million a year.

eLearning Center Schools: The special funding is provided to the auditor general to deliver administrative causes in creating, installing and operating the mastery learning criteria based funding for individual students.

		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Auditor General	0	0.6	1.5	2	1	0.5	0.2	0.2	0.2	0.2	0.2

Table 22

Direct Cost Summary

The current K-12 eLearning cost level contained in eSATS is estimated at approximately $42 million. The total technology-effective classroom cost estimate builds to approximately 8.5 percent of total K-12 funding. This cost is commensurate with the acquisition of information technology with training, professional development, and technical support by other information and knowledge intensive industries.

SUMMARY COSTS											
$Millions		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Teachers											
Profress Dev		15	32	49	67	69	71	74	76	78	80
Mentors		15	32	49	67	69	71	74	76	78	80
eLTEPDI		10	12	14	16	16	16	16	16	16	16
Laptops		31	30	11	10	16	16	15	15	14	14
Curriculum											
Curriculum		19	26	40	61	87	112	140	168	173	178
Curr Experts		9	9	10	10	10	10	11	11	11	12
Instruct Techs		9	9	10	10	10	10	11	11	11	12
Compu/Connect											

Computers		64	70	84	120	150	166	187	197	117	139
IT Director		4	4	4	4	4	4	4	4	5	5
Connectivity		24	25	28	35	43	49	58	66	60	64
Assessment		30	30	31	31	32	33	33	34	35	36
Tech Support		22	30	43	60	81	97	114	128	123	118
Admin ADE ABOR GITA AGO		12	16	19	19	20	21	21	21	20	20
Total Cost $M		**264**	**325**	**390**	**512**	**608**	**678**	**757**	**821**	**741**	**773**
$/Student		269	322	376	478	552	598	648	683	598	606

Table 23

Cost Savings Generated by eLearning

eLearning adoptions in other markets such as workforce and military simulation have shown significant cost savings along with enhanced learning. Many workforce request for proposals that stipulate eLearning solutions require significant cost savings, up to 50%, over traditional training methods. But K-12 is unique and must be assessed in detail. The following scenario develops a quantitative cost reduction forecast. The results have face validity and are supported by pragmatic analysis.

If eLearning online courses are adopted for total replacement or gap filling for legacy courses the direct savings can be significant. A new home-based online high school in Wisconsin contracts with an online company for operations including digital curriculum and technology.[58] The $2,783 cost per student is well under the $5,000 in state aid or $7376 nation average cost for K-12 school students.[59] A county school system is contracting for a fifth grade online pre-algebra course at $150 per student. Typical advance placement courses run $800 and government/economics courses $175 per student.[65] With the average United States program at five courses a year using legacy education costing $1475 each, the savings could be significant. The eSATS design, especially in the primary grades is expected to be initially implemented in the classroom with only some “virtual” school aspects.

These and other savings over legacy education could rapidly surpass the projected 8.5 percent cost of the proposed eSATS design at full operation. There are a number of areas where eLearning may cause significant savings:

- Books and expensive desks to hold books;
- Rooms that house computer labs can be used for classrooms;
- Paper – work sheets, assessments, reports and tests;
- Flexibility in the academic year, location, and size;
- Construction avoidance of legacy schools;
- On-line instruction with one master teacher lecturing to thousands of students;
- Home workstations reduce every school day transportation and cafeteria costs;
- The decrease in time to master subjects summed over 13 academic years could eliminate the cost of one calendar year with early graduation;
- Out sourcing on-line instruction and telephone-email support reduces cost of aids and teachers;

- Teacher professional development cost is reduced by more accessible and effective online eLearning and fewer substitutes and no travel cost;
- Commercial digital content, curriculum, and courseware have large economies of scale;
- Low-priced and free digital content, curriculum, and courseware is available over the Internet including open source products and systems. Determining appropriateness and effectiveness can be cost effective with automated data on 80,000 potential users at each grade level.
- Authoring systems and Web sites provide considerable support for teachers who are capable of creating and sharing their own digital curriculum.
- Full literacy will gradually reduce the numbers of our citizens incarcerated at high cost.
- Successful schools will deliver more quality jobs, accelerated economic development, reduce under and un-employment cost and provide additional tax revenues.

Scenario Assumptions

Over the first ten years of eLearning adoption, the cost decreases for the major areas for each year is estimated, starting in year 2:

- Construction: Repurposing of computer labs - site flexibility reduces need 1%;
- Teachers: Salaries increase 2.0 percent while an increase in efficiency reduces population required by 1.2 percent. Arizona's 3.0 percent growth rate translates into an average net increase in the teacher cadre by 1.8 percent;
- Books, furniture, etc – elimination or less expensive types reduce costs by 2 percent then 3 percent;
- Transportation and food – learning site and time flexibility reduces need by 1 percent;
- Student Population: Learning effectiveness increases year by year early graduation rate by 1 percent while high school retention adds 0.33 percent to student population.

eSATS Cost Reduction Model											
eSATS Analysis	04/05	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Teacher		40.0%									
SalaryIncrease %			2.0%	4.0%	6.0%	8.0%	10.0%	12.0%	14.0%	16.0%	18.0%
PopReduction %			1.2%	2.4%	3.6%	4.8%	6.0%	7.2%	8.4%	9.6%	10.8%
Net Reduction			-0.8%	-1.6%	-2.4%	-3.2%	-4.0%	-4.8%	-5.6%	-6.4%	-7.2%
$/Student	2880		-23	-46	-69	-92	-115	-138	-161	-184	-207
Cost Savings			-24	-49	-76	-103	-131	-160	-190	-222	-254
Construction		10.0%									
Reduction %			1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%
$ /Student	500		5	10	15	20	25	30	35	40	45
Cost Savings			5	11	16	22	28	35	41	48	55
Supplies/Books/Furniture		10.0%									
Reduction %			2.0%	4.0%	7.0%	10.0%	13.0%	16.0%	19.0%	22.0%	25.0%
$ /Student	200		4	8	14	20	26	32	38	44	50
Cost Savings			4	9	15	22	30	37	45	53	61

Transport-Food		10.0%									
Reduction %			1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%
$ /Student	800		8	16	24	32	40	48	56	64	72
Cost Savings			8	17	26	36	45	56	66	77	88
Population			1	2	3	4	5	6	7	8	9
Early Graduation			1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%
Retention	4.0%		0.4%	0.8%	1.2%	1.6%	2.0%	2.4%	2.8%	3.2%	3.6%
Net Reduction			0.6%	1.2%	1.8%	2.4%	3.0%	3.6%	4.2%	4.8%	5.4%
Cost Savings	7200		45	93	142	193	245	300	357	415	476
Total Cost Reductions											
Teacher		0	-24	-49	-76	-103	-131	-160	-190	-222	-254
Construction		0	5	11	16	22	28	35	41	48	55
Supplies/Books/Furniture		0	4	9	15	22	30	37	45	53	61
Transport-Food		0	8	17	26	36	45	56	66	77	88
Population		0	45	93	142	193	245	300	357	415	476
Total Cost Reductions		0	39	80	124	170	218	267	319	372	426
eLearning Costs		176	223	296	403	501	543	603	651	573	599
04/05 eLrng Expenditures		48	48	48	48	48	48	48	48	48	48
New eLearning Costs		128	175	248	355	453	495	555	603	525	551
eLrng Cost Reductions		0	-39	-80	-124	-170	-218	-267	-319	-372	-426
Net Cost of eLearning		128	136	168	231	283	277	288	284	153	124

Table 24

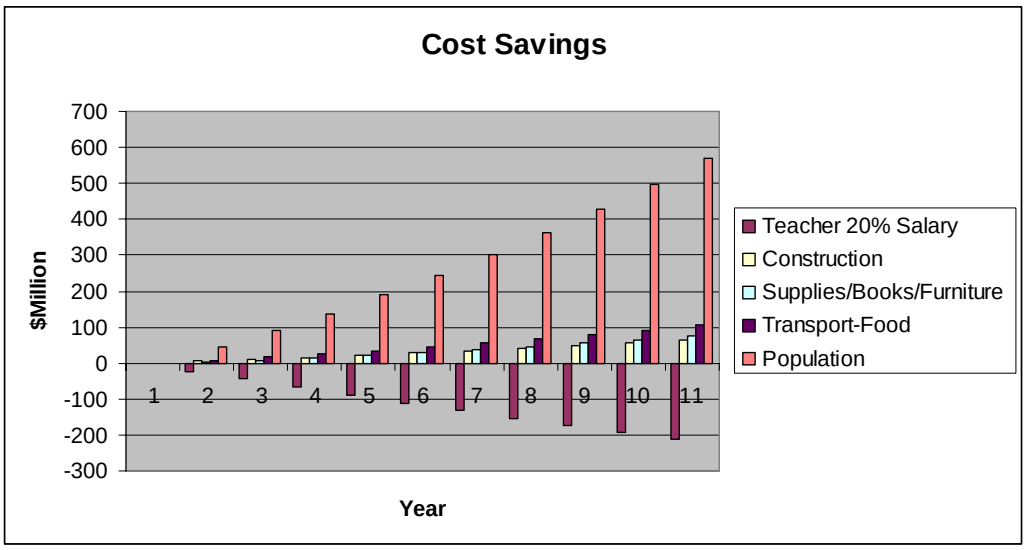


Figure 25

The direct cost of eLearning adoption maximizes at the $700 million level in year eight is reduced by the $42 million already being spent on eLearning in Arizona. But main reduction is the cost savings caused by the effectiveness, efficiency and flexibility of eLearning. These savings keeps the maximum cost of eLearning under the $300 million

level. The cost effectiveness of is apparent in the 5 percent of total education costs will not only increase student academic performance by 30% - one grade level.

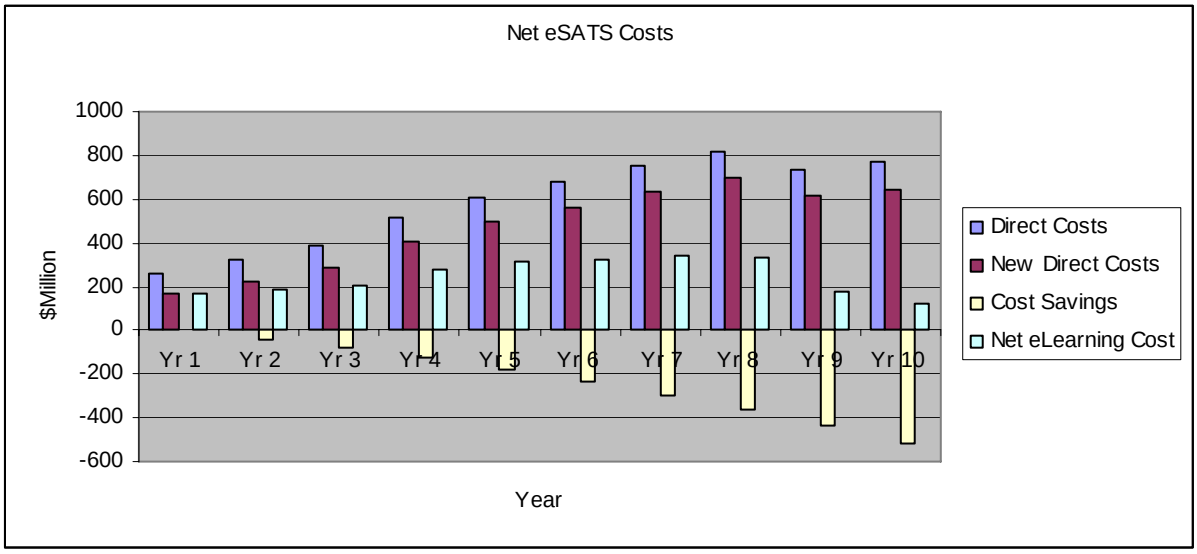


Figure 26

Total and Net eSATS Annual Cost

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Direct Costs	264	326	391	512	607	677	755	818	737	768
New Direct Costs	166	225	287	405	497	564	638	698	613	641
Cost Savings	0	38	80	128	181	238	299	366	439	517
Net eLearning Cost	166	187	207	276	316	326	339	331	174	124

Table 25

Funds Sources

Federal funds that have components that may be used to fund specific aspects of eLearning include eRate, Title I, and No Child Left Behind. The Federal funding specifically for educational technology programs as been discontinued. The available funds are restricted in many cases and have a main focus on the disadvantaged student.

The average federal eRate funding in 2004 was $43 per student. Arizona received $$49 million for 940,000 students. Under eSATS the Arizona Department of Education will be strongly supported to secure all potentially available federal funds to support eSATS implementation. Federal funds can support innovation and ease the cost burden but cannot be counted on for sustained support. Allocation of Arizona funds within the current K-12 funding channels is required.

Most of the funding will come from Arizona taxes and intra-district transfers from cost savings. Detailed design calculations based on better and more current data will provide higher validity cost figures. But the range of new and reallocated Arizona K-12 funds is expected to be in the $100 million range at the initiation of eSATS growing to the $600 million range in the out years. This cost is approximately $100 per student (1.2%) in the being growing to a maximum $500 per student (7%). in the out years

Singapore invested $1.2 billion to bring 500,000 students up to a computer ratio 2:1 ratio five years ago[14]. Their ongoing eLearning investment is $1200 per student per year.[15] Thailand is adopting eLearning to transform its entire K-12 into using English only in the classroom. Arizona is an innovative state with a much higher per-capita income than Singapore and Thailand. We should be able to provide an even better eLearning opportunity for our children.

Ability to Pay:

Current 2002-2003 investment in K-12 education is approximately $6.8 billion of public funds for 940,000 students or $7,200 per student. Goldwater Institute presents $8,500 as the total amount in 2005. This includes the funding from all federal, state, county, and local sources. These funds cover the costs of Arizona Department of Education, County School Offices, pre-service teacher education, facilities construction and repair, transportation, security and food services, teaching and administration, supplies and utilities, special programs… everything. The estimated current expenditure for per student for eLearning is estimated at 1.3 percent or $94 from all sources.

This eSATS cost structure represents medium to large districts. Very small districts of less than 250 students and very rural districts will need minimums in each of the four major cost areas.

In 2004, Arizona's Rodel Foundation conducted a comprehensive study using national expert consultants. The consultants were charged with reviewing the research on all potential K-12 reforms that could improve academic performance. They then developed a program, "Lead with Five," of recommendations (with costs) of the most effect reforms.[73].

Their data indicated that Arizona could move from 44th out of 50 states to average in academic performance if these reforms were adopted statewide. With expected 30% to 40% growth in Arizona's school population over the next ten years the total cost to do nothing to the current system will be $80 billion. The "Lead with Five" improvements would cost an additional $1900 per student, pushing the ten-year cost to approximately $102 billion.

eLearning costs approximately $500 per student-year when fully implemented. The average operational K-12 expenditures for the United States in 2001 were $7,376 per student. Arizona spent $5,319 per student. The national percent of taxable resources spent on education was 3.2 percent compared to the national average of 3.7 percent.[59] If expenditures were raised by $500 (8.6 percent) to $5,819 Arizona would still only be at 79 percent what the average United States citizen is paying for education of their states children. Ability to pay from taxable resources remains under the national average at 3.5 percent.

eLearning implementation is not a one-time special funding project but must become a regular set of line items in the K-12 Maintenance and Operations (M&O) budget. eLearning fund law (section 5.6) will set the accounting and budgeting regulations that provide continuity and stability.

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Appendix B
2005 Senate Bill SB1181Sections Relating to Design Components

System Design: Innovation Central and Six Major Components

Human Ecosystem

K-12 human ecosystem center

a. The department of education shall establish and fund a K-12 human ecosystem center that will deliver human ecosystem policy and advice to all aspects of Arizona K-12 education system and particularly those who are creating, developing and supporting eLearning centered schools. The K-12 human ecosystem center will be staffed with experts from the five major human ecosystem disciplines: microsystem, mesosystem, exosystem, macrosystem and chronosystem and also with community and school outreach professionals.

b. The primary mission of the K-12 human ecosystem center is to develop practical policies to be applied in Arizona. These policies will be used to effectively engage all aspects of the student's human ecosystem to significantly increase the student's academic performance and probability for graduation. These policies will address all K-12 students regardless of demographic or academic situation of the student. It is expected that the family and the school will be the most critical aspects of the student microsystem on which the K-12 human ecosystem center will focus their efforts.

c. Arizona department of education data systems and Arizona schools will be major components to support the field testing of K-12 human ecosystem center policies and providing ongoing data and assessments for policy enhancement and redesign.

d. The human ecosystem center may be operated within or as an affiliate of the Arizona center for the future of Arizona.

3.1 Teacher and Staff Education and Professional Development

15-1058. <u>Teacher and administrative staff professional development</u>

E-learning professional development for in-service teachers and administrative staff shall be supported with master-mentor teachers, education and professional development. E-learning centered schools shall provide on staff one master-mentor e-learning teacher for every fifty teachers. The master-mentor e-learning teacher is responsible for in classroom mentoring and developing individualized professional development programs for each teacher in that school. The department of education shall provide monies to the school district and charter school for the master-mentor teachers and the individualized professional development programs. The maximum annual distribution by the department of education pursuant to this section shall not exceed more than two thousand five hundred dollars per teacher.

15-1650. <u>E-learning education and professional development</u>

A. The Arizona board of regents and the department of education shall establish an e-learning education and professional development institute for teachers and administrative staff. The institute shall develop and update education and professional development curriculum policy criteria and standards. The policy, criteria and standards shall include e-learning subjects and issues including teaching, administration, information technology, technical support, communications, digital curriculum, home and community involvement and leadership. The criteria and standards shall address preservice education, postgraduate education, in-service professional development and teacher and administrator certification. The criteria and standards shall address teacher specific areas, including grade level, subject matter, digital curriculum, digital assessment, individual learning capability and knowledge of students. Certification at specified levels of e-learning competency for teachers and administrative staff shall be provided by the department of education. These competency levels for teachers shall range from an entry level use of computers to master-mentor e-learning teacher.

B. Teachers who advance in e-learning competency as demonstrated by certification and classroom practice effectiveness and efficiency shall be rewarded with salary increases equal to a maximum of twenty per cent over ten years, not including other salary or cost of living increases.

C. The e-learning education and professional development institute shall search out, assess and approve potential providers of e-learning education and professional development that provide services to teachers and administrative staff. These providers may be public or private, for profit or nonprofit, preservice, graduate or professional development schools, consultants, programs, community colleges, county consortiums or universities. Services delivered pursuant to this subsection may be obtained on line or in any other appropriate manner. Providers shall be requested to support the development of the institute's criteria and standards. Provider offerings that meet specific aspects of the institute's criteria and standards shall be recommended by the institute.

D. If there is no provider offering that matches specific aspects of the institute's criteria and standards, the institute shall attempt to persuade suitable providers to develop these offerings.

E. The public colleges of education in this state shall transform their courses of study for preservice education to graduate teachers who can pass certification requirements specified by the department of education. The entry level preservice certification shall be positioned within the appropriation or transformation level of institute's criteria. The certification shall allow entry level teachers to limit the certification subjects and grade levels, to which they are certified, within the e-learning criteria and standards. The public colleges of education in this state shall transform their graduate courses of study to support development of teachers and administrators to the highest level of certification by the department of education.

3.2 Digital Curriculum

Section. 4. Title 15, chapter 13, article 2, Arizona Revised Statutes, is amended by adding sections 15-1649 and 15-1650, to read:

15-1649. Digital curriculum institute

A. The Arizona board of regents shall establish a digital curriculum institute within the Arizona university system the digital curriculum institute shall provide digital curriculum experts to evaluate digital curriculum from all sources that claim to have application in the classroom. The results of the evaluation shall be published on a web site maintained by the institute in a manner in which the information is accessible to school districts and charter schools. The evaluation shall include the extent to which the digital curriculum accomplishes each of the following:

1. Increases academic performance.

2. Supports the academic standards adopted by the state board of education.

3. Is grade level appropriate.

4. Is easy to use.

5. Motivates the student to learn.

6. Is transferable.

7. Provides formative assessment data to students and teachers.

B. The digital curriculum institute shall provide an extension service that uses instructional technologists to deliver assistance and support to school district and charter school curriculum directors and teachers in the classrooms. The institute shall also deliver on-line support to facilitate the adoption of the most appropriate digital curriculum to suit the individual student's academic needs.

C. The digital curriculum institute may use the services of other state agencies, individuals and organizations that have expertise in digital curriculum and extension services.

3.3. Assessment - Access - Accountability - Decision Support

Section. 2. Title 15, chapter 9, article 8, Arizona Revised Statutes, is amended by adding section 15-1044, to read:

15-1044. Data system for accountability; support

The department of education shall accelerate the development and deployment of the student accountability and information system with internet web based services to assure full operation by the beginning of the 2007-2008 school year. Adequate support shall be provided to school districts and charter schools to assure that data collection, databases, input, analysis and reporting are compatible with the student accountability information system. The student accountability information system shall be expanded to include all significant data with respect to public education, early childhood education and care,

English language learners, special education, minority access and participation, teacher quality, school administration, school accountability, assessment of student learning, parental choice, school funding, e-learning adoption, cost savings due to e-learning, student environment systems, parents, business, educational and social agency support and postsecondary longitudinal success. The student accountability and information system shall provide accountability data, identify improvement areas and support alignment of resources to improve student academic performance and retention until graduation.

Section. 5. Title 15, chapter 16, article 2, Arizona Revised Statutes, is amended by adding section 15-2012, to read:

15-2012. Instructional system for e-learning and communication

The department of education shall evaluate current statewide e-learning instructional support and communication systems. Based on this evaluation and prospects of emerging technology, the system shall be redesigned if needed and implemented with a ten year growth capacity. The system shall provide networking and communications capability with digital curriculum transport and e-learning implementation service for all schools in this state and their communities. This system shall provide access to statewide and global resources, and instruction delivery shall include student education, teacher and administrative staff education and professional development. This open system shall be used by the digital curriculum institute, the e-learning education and professional development institute, digital curriculum providers, education and professional development providers and researchers to serve student, teacher and administrative staff clients.

3.4. Computers and Connectivity

Section 1. Title 15, chapter 9, article 4, Arizona Revised Statutes, is amended by adding section 15-962.02, to read:

15-962.02. Teachers; hardware and software

A. The department of education shall assure that every teacher has a modern multimedia laptop computer or other type of computing system that effectively links the teacher's residence with the classrooms. The computing system shall be loaded with a suite of essential administrative, connectivity, data entry, subject matter specific, professional development and productivity software and shall include a classroom projector and high-speed connectivity at both the school and the teacher's residence. The public colleges of education in this state shall support the specification, design and development of the suite of essential software through research and expertise in collaboration with school districts, charter schools and e-learning enterprises with experience in this field.

B. The department of education shall collaborate with the government information technology agency established by section 41-3502 to assure that all school districts and charter schools attain equity of access to e-learning with cost-effective broadband

connectivity. Efforts shall be pursued to bring cost-effective broadband connectivity to all rural and underserved school districts and charter school operations by the 2007-2008 school year. The department of education shall assure that school districts and charter schools receive an appropriate share of federal funding for broadband connectivity.

3.5. Technical Support

3.6. Learning Centered Schools

Section. 3. Title 15, Arizona Revised Statutes, is amended by adding chapter 9.1, to read:

Chapter 9.1

Alternative school district and charter school; Budgeting and financial assistance

Article 1. General provisions

15-1051. General provisions for alternative school budgeting and financial assistance; approval; program termination

A. The department of education shall provide alternative budgeting and financial assistance on a school by school basis, as provided in this chapter and in lieu of the budgeting and financial assistance provided pursuant to chapter 9 of this title.

B. The auditor general, in cooperation with the department of education, shall review existing audit compliance requirements for school districts and charter schools to determine compatibility with the budgeting and financial requirements established by this chapter and to develop audit compliance requirements for school districts and charter schools pursuant to this chapter.

C. Schools within school districts and charter schools that apply for participation under the alternative budgeting and financial assistance prescribed in this chapter are not subject to chapter 9 of this title.

D. A school district or charter school is not eligible for alternative budgeting and financial assistance pursuant to this chapter unless the department of education approves the school through a written agreement executed pursuant to section 15-1054.

15-1052. E-learning centered school system; purpose; scope

A. E-learning centered schools may be established under this chapter to offer students a comprehensive academic program delivered through a variety of e-learning methods and digital technologies intended to assure every student the opportunity to meet and exceed the academic standards adopted by the state board of education at every grade level.

B. E-learning centered schools may consist of new charter schools, existing charter schools or all or any portion of an existing school district. All e-learning centered schools remain public schools.

C. E-learning centered schools shall comply with this chapter in order to receive the state funding authorized under this chapter.

15-1053. E-learning centered schools; criteria

A. For a school to be identified as an e-learning centered school under this chapter, the school shall meet all of the following minimum criteria:

1. The school has adopted a curriculum that is fully aligned with the academic standards adopted by the state board of education for each grade level offered at the school.

2. At least fifty per cent of the adopted curriculum is delivered using digital curriculum and the remainder of the curriculum is supported by e-learning tools where appropriate.

3. The entire curriculum is individual student paced and matched to each student's documented academic competency level as measured by formative assessments.

4. The school has the necessary e-learning equipment, connectivity and systems to assure that every student has immediate classroom access to appropriate digital curriculum.

5. The instructional staff has obtained substantial education and training in the delivery of academic curriculum through the e-learning process

6. The school has systematic access to e-learning education and professional development, including mentoring by master-mentor teachers.

7. The school has instituted a data based system that provides immediate access to assessment of academic progress by the student, parent, instructional staff, administration and department of education for guidance and decision support.

8. The school has an established evaluation system that provides periodic review of adopted e-learning technologies and methods, new e-learning technologies and other methods that become available in the future.

9. The school has instituted a continuous e-learning upgrade and adoption program as provided in this chapter to improve the academic performance of students and to provide data to e-learning providers for improvement of products and services.

10. The school has an annually updated plan for e-learning technology, digital curriculum and education and professional development.

11. The school organizes and continuously supports an e-learning parent and community advocacy group to facilitate the e-learning transformation in the classroom, in the homes of students and in the community.

B. Except as provided in section 15-1054, subsection B, a school shall not be identified as an e-learning centered school unless the school certifies that the school has met or exceeded all of the criteria prescribed in this section.

15-1054. Approval of e-learning centered schools; provisional approval; termination of approval

A. The department of education shall approve schools as e-learning centered schools based on the department of education's review of an application submitted by the school district within which the school is located or by the governing body of the charter school. The approval shall be in the form of a written agreement signed by the superintendent of public instruction and by the school district governing board or the governing body of the charter school. The agreement shall be in effect for an initial period of ten years which may be extended on written agreement of all parties to the agreement. The agreement may not be modified except on written agreement of all parties to the agreement.

B. The department of education may grant provisional approval of an e-learning centered school with an agreement to be in effect for a period not to exceed five years to a school that does not yet meet the minimum criteria prescribed in section 15-1053 if the application submitted identifies the unmet criteria and indicates the method and timeframe by which the criteria will be met.

C. The department of education may terminate approval of an e-learning centered school if the department of education, after investigation and notification of the school, determines that the school is not in compliance with this chapter or the agreement.

15-1055. Application; review process

A. A school district or charter school may submit an application to participate in the e-learning centered school program on behalf of one or more schools on forms developed by the department of education. The application shall contain the following information:

1. A profile of each school for which the application is submitted that contains the following information:

(a) the number of students and grade levels offered and the ratio of pupils to teachers.

(b) the current school achievement profile pursuant to section 15-241.

(c) a description of any special programs offered at the school, including gifted programs, special education programs, English language learner programs and remediation programs for the Arizona instrument to measure standards test and the number of students who participate in each program.

(d) the number of, experience levels of and educational background of the teaching staff, the classroom support staff and the administrative staff.

2. A specific assessment of the criteria specified in section 15-1053, including documentation that supports any assessment that indicates that the school has met or exceeded any of the prescribed criteria.

3. An identification of changes to the existing curriculum that would be adopted after approval of the application, including appropriate timelines that reflect the estimated adoption, any education and professional development that will be required and an estimate of the time at which the e-learning centered program will be fully implemented into classroom instruction.

4. The detailed strategies, including timelines, that the school will use to meet or exceed each criterion that has not been met according to the assessment required in paragraph 2.

5. A proposed operational and capital budget for the school as prescribed in section 15-1056 for e-learning centered schools. The budget shall reflect any additional support to be provided by the school district or charter school beyond the funding formula for e-learning centered schools.

B. The department of education shall review each application and, within sixty days after receipt of the application, determine whether the application meets the requirements of this chapter. If the application meets the requirements of this chapter, the department of education shall submit a written agreement to the school district or charter school that includes the specific obligations that the school shall undertake based on the application and subsequent negotiations between the department of education and the applicant. The agreement shall also include identification of the specific criteria to be used to determine student academic progress.

C. Before approving an application, the department of education may request modifications to the application, send representatives to visit the school site and request additional supporting documentation for information included in the application.

D. If the department of education, after review of the application, does not approve the application, the department of education shall notify the applicant in writing of the department's decision and provide the applicant with the specific reasons that the department did not approve the application. If the applicant is a school district, the applicant, within thirty days after receiving notice from the department of education that the application has not been approved, may submit a written appeal to the state board of education for review pursuant to title 41, chapter 6, article 10. If the applicant is a charter school, the applicant, within thirty days after receiving notice from the department of education that the application has not been approved, may submit a written appeal to the state board for charter schools for review pursuant to title 41, chapter 6, article 10.

15-1056. <u>E-learning centered schools; budgeting; financing</u>

A. Each school that has been approved as an e-learning centered school shall annually submit to the department of education a budget that is based on the school's estimate of the per student amount of funding necessary to advance each student one full academic year and any additional monies from any other sources, including monies from the school district or charter school. Each student's academic progress shall be based on assessment criteria that are identified in the written agreement between the department of education and the school district or charter school pursuant to section 15-1055. The academic year of each student in an e-learning centered school may be longer or shorter than the calendar academic year. The length of a student's academic year begins when the student starts the academic year and ends on the date that the student has mastered the learning required by the academic standards adopted by the state board of education.

B. The per student amount estimated by an e-learning centered school shall not exceed the per student statewide average expenditure for the previous fiscal year, except that the department of education may provide for additional e-learning allowances.

C. The budget submitted to the department of education pursuant to subsection a of this section shall be in a format approved by the department of education and shall contain distinct sections for the estimated per student funding and additional monies from other sources.

D. The distinct sections of the budget prescribed in subsection c of this section shall include each of the following:

1. The classroom operational costs, including salaries for instructional staff and support staff.

2. The administrative costs, including costs related to assessment, data collection, data storage and reporting.

E. The department of education shall include in the department of education's annual budget request an estimated amount for basic funding of e-learning centered schools based on the estimated number of students enrolled in the approved schools multiplied by the statewide average per student expenditure from the prior year.

F. Additional monies that are not based on per pupil funding shall be allocated to the entities specified by the department of education for the e-learning centered schools. These e-learning specific costs include education and professional development, performance incentives, mentoring, computers, interfaces, software, digital curriculum, connectivity and technical support.

15-1057. <u>School district and charter school budget adjustment</u>

School districts and charter schools that have one or more e-learning centered schools shall not include the average daily membership of those schools in their student count computed pursuant to section 15-185 or section 15-902. A school district or charter school may use the average daily membership of e-learning centered schools to calculate funding for services that the school district or charter school continues to provide to the e-

learning centered school, including pupil transportation, food services, building maintenance and repair.

Section. 6. Initial approval; limitation

The department of education may review applicants for e-learning centered schools pursuant to title 15, chapter 9.1, Arizona Revised Statutes, as added by this act, but shall not approve more than one hundred schools as e-learning centered schools in the 2005-2006 school year to start operations in the 2006-2007 school year, shall not approve more than three hundred schools in the 2006-2007 school year and shall not approve more than five hundred schools in the 2007-2008 school year.

5. COSTS AND FUNDING

Section. 7. Appropriations; board of regents

A. The sum of $30,000,000 is appropriated from the state general fund to the Arizona board of regents in fiscal year 2005-2006 to carry out the purposes of section 15-1649, Arizona Revised Statutes, as added by this act.

B. The sum of $8 1,500,000 is appropriated from the state general fund to the Arizona board of regents in fiscal year 2005-2006 to carry out the purposes of section 15-1650, Arizona Revised Statutes, as added by this act.

Section. 8. Appropriations; department of education

A. The sum of $8,500,000 is appropriated from the state general fund to the department of education in fiscal year 2005-2006 to carry out the purposes of section 15-1650, Arizona Revised Statutes, as added by this act.

B. The sum of $30,000,000 is appropriated from the state general fund to the department of education in fiscal year 2005-2006 to carry out the purposes of section 15-962.02, subsection A, Arizona Revised Statutes, as added by this act.

C. The sum of $30,000,000 is appropriated from the state general fund to the department of education in fiscal year 2006-2007 to carry out the purposes of section 15-962.02, subsection A, Arizona Revised Statutes, as added by this act.

D. The sum of $2,000,000 is appropriated from the state general fund to the department of education in fiscal year 2005-2006 to carry out the purposes of section 15-962.02, subsection B, Arizona Revised Statutes, as added by this act.

E. The sum of $3,000,000 is appropriated from the state general fund to the department of education in fiscal year 2006-2007 to carry out the purposes of section 15-962.02, subsection B, Arizona Revised Statutes, as added by this act.

F. The sum of $10,000,000 is appropriated from the state general fund to the department of education in fiscal year 2005-2006 to carry out the purposes of section 15-1044, Arizona Revised Statutes, as added by this act.

G. The sum of $10,000,000 is appropriated from the state general fund to the department of education in fiscal year 2006-2007 to carry out the purposes of section 15-1044, Arizona Revised Statutes, as added by this act.

H. The sum of $10,000,000 is appropriated from the state general fund to the department of education in fiscal year 2007-2008 to carry out the purposes of section 15-1044, Arizona Revised Statutes, as added by this act.

I The sum of $2,000,000 is appropriated from the state general fund to the Department of Education in fiscal year 2005-2006 to carry out the purposes of section 15-2012, Arizona Revised Statutes, as added by this act.

J The sum of $33,000,000 is appropriated from the state general fund to the department of education in fiscal year 2005-2006 to carry out the purposes of title 15, chapter 9.1, Arizona Revised Statutes, as added by this act. The department of education may retain $2,000,000 of these monies to provide administration functions to fund and support e-learning centered schools.

K. The sum of $157,000,000 is appropriated from the state general fund to the department of education in fiscal year 2006-2007 to carry out the purposes of title 15, chapter 9.1, Arizona Revised Statutes, as added by this act. The department of education may retain $3,000,000 of these monies to provide administration functions to fund and support e-learning centered schools.

L. The sum of $317,000,000 is appropriated from the state general fund to the department of education in fiscal year 2007-2008 to carry out the purposes of title 15, chapter 9.1, Arizona Revised Statutes, as added by this act. The department of education may retain $4,000,000 of these monies to provide administration functions to fund and support e-learning centered schools.

M. The sum of $452,000,000 is appropriated from the state general fund to the department of education in fiscal year 2008-2009 to carry out the purposes of title 15, chapter 9.1, Arizona Revised Statutes, as added by this act. The department of education may retain $5,000,000 of these monies to provide administration functions to fund and support e-learning centered schools.

Section. 9. <u>Appropriations; government information and technology agency</u>

A. The sum of $200,000 is appropriated from the state general fund to the government information and technology agency in fiscal year 2005-2006 to carry out the purposes of section 15-962.02, subsection B, Arizona Revised Statutes, as added by this act.

B. The sum of $200,000 is appropriated from the state general fund to the government information and technology agency in fiscal year 2006-2007 to carry out the purposes of section 15-962.02, subsection B, Arizona Revised Statutes, as added by this act.

APPENDIX C

Arizona Enterprises comprising eLearning Cluster

21st CENTURY LEARNING	Phoenix
ACADEMY SERVICE	Sierra Vista
ACTIVE ARIZONA AUTOMATION	Phoenix
ALTURA	Phoenix
AMES BUSINESS & LEARNING ENVIRONMENTS, INC	Chandler
APOLLO GROUP, INC	Phoenix
APOLLO-WESTERN INTERNATIONAL UNIVERSITY	Phoenix
APPLE CORPORATION	Phoenix
ARIES TECHNOLOGY INC	Tempe
ARIZONA SCHOOL OF HEALTH SCIENCES	Mesa
ARIZONA SCHOOL SERVICES THROUGH EDUCATIONAL TECHNOLOGY	Phoenix
ASSESSMENT TECH. INC.	Tucson
AT&T	Phoenix
BAY 6 PRODUCTIONS	Scottsdale
BELL SYSTEMS	Scottsdale
BEVCOM/COGNIGEN NETWORKS Inc	Tucson
BHR SOFTWARE	Tucson
BLACKBOARD	Phoenix
BLACKERBY ASSOCIATES	Phoenix
BROADBAND LABORITORIES	Tucson
CALENCE	Tempe
CCI NETWORKS INCORPORATED	Phoenix
CCS PRESENTATION SYSTEMS	Tucson
CDI LRNG & PERF MNGMENT	Phoenix
CENTERLINE EDUCATIONAL SERVICES	Phoenix
CHARTER LEARNING	Phoenix
CISCO SYSTEMS INC.	Phoenix
CLH INTERNATIONAL	Tempe
Cn-LEARN	Phoenix
CO-NECT	Higley
COMPASS LEARNING	Phoenix
COMPUTER DIAGNOSTICS AND DESIGN	Phoenix
CONCORDS'S VIRTUAL CYBER SYSTEM INC	Tempe
CONSERVA LEARNING CENTERS	Phoenix
CoRESOURCES TECHNOLOGY CORP	Phoenix
CORPEDIA TRAINING TECHNOLOGIES	Phoenix
COX BUSINESS SYSTEMS	Phoenix
CULINARY CONNECT	Oro Valley
CURRENT TRAINING & CONSULTING	Tempe

CYRACOM INTERNATIONAL	Tucson
DANDELION BOOKS	Tempe
DARCOMM NETWORK SOLUTIONS	Tucson
DATAPAX	Phoenix
DATASOFT CORPORATION	Tempe
DELL	Phoenix
DESERT HORIZONS	Tucson
DESERT SKY SOFTWARE	Phoenix
DIGITAL CONCEPTS INC.	Scottsdale
E2002 INC	Scottsdale
EDGEPOINT TECHNOLOGY	Phoenix
EDUCATIONAL OPTIONS	Tempe
ELITE PC	Tempe
ELLUMINATE	East Valley
ELTRAX	Scottsdale
EMERGE.MD	Phoenix
EMSQUARE RESEARCH INC	Scottsdale
EMSQUARE RESEARCH INC	Scottsdale
ENSYNCH	Glendale
EVANS NEWTON CORP	Scottsdale
EXECUTRAIN	Tucson
FANTASY STOCK MARKET	Scottsdale
FORESITE TECHNOLOGIES	Tempe
FOUR CORNERS TECHNOLOGY INC	Cave Creek
FRED G. ACOSTA JOB CORPS CENTER	Tucson
FRONT END SOFTWARE SERVICES INC	Tucson
FUJITSU	Phoenix
FutureKids	Prescott
GEOLEARNING INC.	Phoenix
GHA TECHNOLOGIES	Scottsdale
GLASSGOW PROFESSIONAL DEVELOPMENT	Scottsdale
GLOBALLITERACY INC	Phoenix
GNOSIS INTERACTIVE	Phoenix
GREAT SCOTT ENTERPRISES INC.	Tucson
HAIKU PRODUCTIONS	Phoenix
HALL KINION	Mesa
HEALTH COACH	Phoenix
HEWLETT-PACKARD Co.	Tempe
IBM	Phoenix
IKON ACADEMIC RESEARCH AND TECHNOLOGIES	Phoenix
iLINK COMMUNICATIONS	Phoenix
IMAGETAG	Chandler
IN LYNX	Phoenix

INFLOW	Phoenix
INFOLINK SOLUTIONS LLC	Scottsdale
INFORMATION GROUP INC	Scottsdale
INSIGHT	Tempe
INSTASOFT	Claypool
INTEGRATED INFORMATION SYSTEMS	Tempe
INTEGRATED LEARNING SOLUTIONS	Tucson
INTEL CORPORATION	Chandler
INTERACTIVE ALCHEMY	Phoenix
INTERNATIONAL CROSSING	Scottsdale
INTERNATIONAL IMPORT-EXPORT INSTITUTE	Glendale
INTERNATIONAL INTERNET & TELECOM	Phoenix
INTERNET INSTITUTE USA	Phoenix
INTERSIL	Scottsdale
INXSOL	Phoenix
ISR	Tucson
JDA SOFTWARE GROUP INC	Gilbert
JES & CO	Tucson
JUDITH MCMANUS & ASSO.	Tucson
KIDS123	Danville
KIDSLEARNING	Sedona
KINO DIGITAL LLC	Tucson
KNOWCONFLICT, LLC	Tucson
KNOWLEDGENET	Scottsdale
LEARN IT!	Phoenix
LEARN2 INC	Chandler
LEARNING APPEAL INC.	Scottsdale
LEARNINGSTATION	Phoenix
LEGALSPAN INC.	Gilbert
LEWIS DESIGN ASSOCIATES	Scottsdale
LITERACY COMPANY (THE)	Scottsdale
LITTLE GYM (THE) INTERNATION, INC.	Scottsdale
LUCENT TECHNOLOGIES	Scottsdale
LUTCF	Tucson
MANAGE GREAT	Ahwatukee
MANAGEMENT ACTION PARTNERS	Phoenix
MANPOWER PROFESSIONAL	Tucson
MAPLEGATE TECHNOLOGIES LLC	Tucson
MARICOPA COMMUNITY COLLEGE DISTRICT	Tempe
MAYO CLINIC - HOSP SCOTTSDALE	Scottsdale
MEETANYTIME	Tucson
MICROBUSINESS ADVANCEMENT CENTER OF SOUTHERN ARIZONA	Tucson

MICROSOFT CORP.	Phoenix
MOUNTAIN TELECOM	Scottsdale
MSS TECHNOLOGIES	Phoenix
MUDOC CORPORATION	Phoenix
NEOPLANET	Phoenix
NETBEAM	Mesa
NETWORK APPLIANCE	Scottsdale
NETWORK INFRASTRUCTURE CORP	Tempe
NETWORK SERVICES INC	Phoenix
NORSTAN	Phoenix
NPOWER ARIZONA	Tempe
NTEGRA, INC	Phoenix
OPEN VES	Paradise Valley
ORACLE CORPORATION	Phoenix
OUTLOOK TECHNOLOGIES INC.	Phoenix
OVEREAZY MULTIMEDIA PRODUCTIONS	Tempe
PCS/PHOENIX COMMUNICATION SYSTEMS INC.	Phoenix
PEARSON DIGITAL LEARNING	Mesa
PEARSON DIGITAL LEARNING	Scottsdale
PERSISTECH	Tucson
PINNACLE EDUCATION	Tempe
PLAYBACK MEDIA CORPORATION	Phoenix
PLEXUS SCIENTIFIC CORP	Tucson
PREMIER LEARNING SOLUTIONS	Scottsdale
PREMISE ONE INC	Gilbert
QUALITY COMPUTER TRAINING SERVICES	Avondale
QWEST	Phoenix
R*SMART GROUP (THE)	Phoenix
RESULTSDIRECT.COM	Tucson
ROSETTASTONE	Scottsdale
RURALWEST	Scottsdale
SCIENTIFIC LEARNING	Tucson
SCRIPTSAVE	Tucson
SIGMA DATA SYSTEMS INC	Tucson
SIMBA EDUCATION	Scottsdale
SIX SIGMA QUAL TECH	Tempe
SMART CORPORATION	Chandler
SOFTRAIN	Glendale
SOS eLearning	Glendale
SOUTH MOUNTAIN RADIO	Phoenix
SPARTICOM LINKTIVITY	Tucson
SPRINT	Phoenix

TEACHMASTER	Phoenix
TELEPORT COMMUNICATIONS GROUP	Phoenix
THOMPSON/NETG	Scottsdale
THUNDERBIRD E-LEARNING	Glendale
TIME WARNER TELECOM	Tucson
TOHONO O'ODHAM NATION	Sells
TOTAL TRAINING SOLUTIONS	Tucson
TRACORP INC.	Phoenix
TRAINABILITY	Scottsdale
TRAINING PLACE (THE)	Tucson
TRAINING ALA CARTE	Phoenix
TRAINING SOLUTIONS	Tempe
TRIWEST HEALTHCARE ALLIANCE	Phoenix
TROXELL COMMUNICATIONS INC	Phoenix
TUCSON COMMUNITY CABLE CORPORATION	Tucson
TUCSON-PIMA LIBRARY	Tucson
TYPE A MEDIA NETWORK	Mesa
UNICON INC	Chandler
UNIVERSAL TECHNICAL INSTITITUE	Phoenix
USTESTPREP	Phoenix
VOLERA	Orem
WAVE THOMSON LEARNING	Chandler
WAVEPHORE	Phoenix
WEB ELEARNING	Chandler
WILTEL	Tempe
ZEMA TRAINING SYSTEMS	Tempe

Appendix D

International Society for Technology in Education K-12 Professional Development Framework for eLearning[2]

1. Technical Support 2. Advanced Technical Support 3. Teaching Fundamentals 4. Teaching Integration 5. Leadership

ISTE Program Standard		ISTE Performance Standard Educators will.		Personnel Recommendations
1.1	Candidates will use computer systems, run software; to access, generate and manipulate data and to publish results. They will also evaluate performance of hardware and software components of computer systems and apply basic troubleshooting strategies as needed. (Fundamentals)	1.1.1	Operate a multimedia computer system with related peripheral devices to successfully install and use a variety of software package.	Highly recommended for all classroom instructors, classroom support personnel, site/district administration/support staff, library/media specialists and technical support personnel (Basic and Advanced).
		1.1.2	Use terminology related to computers and technology appropriately in written and oral communications	
		1.1.3	Describe and implement basic troubleshooting techniques for multimedia computer systems with related peripheral devices.	
		1.1.4	Use imaging devices such as scanners, digital cameras, and/or video cameras with computer systems and software.	
		1.1.5	Demonstrate knowledge of uses of computers and technology in business, industry, and society.	
1.2	Candidates will apply tools for enhancing their own professional growth and productivity. They will use technology in communicating, collaborating, conducting research, and solving problems. In addition, they will plan and participate in activities that encourage lifelong learning and will promote equitable, ethical, and legal use of computer/technology resources. (Fundamentals)	1.2.1	Use productivity tools for word processing, database management, and spreadsheet applications.	Highly recommended for all classroom instructors, site/district administration/support staff and library/media specialists. Understanding of skills by classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		1.2.2	Apply productivity tools for creating multimedia presentations.	
		1.2.3	Use computer-based technologies including telecommunications to access information and enhance personal and professional productivity.	
		1.2.4	Use computers to support problem solving, data collection, information management, communications, presentations, and decision making.	
		1.2.5	Demonstrate awareness of resources for adaptive assistive devices for student with special needs.	
		1.2.6	Demonstrate knowledge of equity, ethics, legal, and human issues concerning use of computers and technology.	
		1.2.7	Identify computer and related technology resources for facilitating lifelong learning and emerging roles of the learner and the educator.	
		1.2.8	Observe demonstrations or uses of broadcast instruction, AV conferencing, and other distant learning applications.	
1.3	Candidates will apply computers and related technologies to support instruction in their grade level and subject areas. They must plan and deliver instructional units that integrate a variety of software, applications, and learning tools. Lessons developed must reflect effective grouping and assessment strategies for diverse populations. (Integration)	1.3.1	Explore, evaluate, and use computer/technology resources including applications, tools, educational software and associated documentation.	Highly recommended for all classroom instructors, and library/media specialists. Understanding of skills by site/district administration and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		1.3.2	Describe current instructional principles, research, and appropriate assessment practices as related to the use of computers and technology resources in the curriculum.	
		1.3.3	Design, deliver, and assess student learning activities that integrate computers/technology for a variety of student grouping strategies and for diverse student populations.	
		1.3.4	Design student learning activities that foster equitable, ethical, and legal use of technology by students.	
		1.3.5	Practice responsible, ethical and legal use of technology, information, and software resources.	
2.1	Candidates will apply concepts and skills in making	2.1.1	Describe the historical development and important trends affecting	Highly recommended for all classroom instructors

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	decisions concerning social, ethical, and human issues related to computing and technology. (Leadership)		the evolution of technology and its probable future roles in society.	and library/media specialists.
		2.1.2	Describe strategies for facilitating consideration of ethical, legal, and human issues involving school purchasing and policy decisions.	Understanding of skills by site/district administration and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
2.2	Candidates integrate advanced features of technology-based productivity tools to support instruction. (Integration)	2.2.1	Use advanced features of word processing, desktop publishing, graphics programs and utilities to develop professional products.	Highly recommended for all classroom instructors, and library/media specialists.
		2.2.2	Use spreadsheets for analyzing, organizing and displaying numeric data graphically.	Understanding of skills by site/district administration and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		2.2.3	Design and manipulate databases and generate customized reports.	
		2.2.4	Use teacher utility and classroom management tools to design solutions for a specific purpose.	
		2.2.5	Identify, select, and integrate video and digital images in varying formats for use in presentations, publications and/or other products.	
		2.2.6	Apply specific-purpose electronic devices (such as, a graphing calculator, language translator, scientific probeware, or electronic thesaurus) in appropriate content areas.	
		2.2.7	Use features of applications that integrate word processing, database, spreadsheet, communication, and other tools.	
2.3	Candidates will use telecommunications and information access resources to support instruction. (Integration)	2.3.1	Access and use telecommunications tools and resources for information sharing, remote information access and retrieval, and multimedia/hypermedia publishing.	Highly recommended for all classroom instructors, and library/media specialists.
		2.3.2	Use electronic mail and web browser applications for communications and for research to support instruction.	Understanding of skills by site/district administration and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		2.3.3	Use automated on-line search tools and intelligent agents to identify and index desired information resources.	
2.4	Candidates will use computers and other technologies in research, problem solving, and product development. Candidates use a variety of media, presentation, and authoring packages; plan and participate in team and collaborative projects that require critical analysis and evaluation; and present products developed. (Integration)	2.4.1	Identify basic principles of instructional design associated with the development of multimedia and hypermedia learning materials.	Highly recommended for all classroom instructors, and library/media specialists.
		2.4.2	Develop simple hypermedia and multimedia products that apply basic instructional design principles.	Understanding of skills by site/district administration and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		2.4.3	Select appropriate tools for communicating concepts, conducting research, and solving problems for an intended audience and purpose.	
		2.4.4	Participate in collaborative projects and team activities.	
		2.4.5	Identify examples of emerging programming, authoring, or problem	

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	solving environments. 2.4.6 Collaborate in on-line workgroups to build bodies of knowledge around specific topics. 2.4.7 Use a computer projection device to support & deliver oral presentations. 2.4.8 Design and publish simple on-line documents that present information and include links to critical resources. 2.4.9 Develop instructional units that involve compiling, organizing, analyzing, and synthesizing of information and use technology to support these processes. 2.4.10 Conduct research and evaluate on-line sources of information that support and enhance the curriculum.	
3.1 Candidates will effectively plan, deliver, and assess concepts and skills relevant to educational computing and technology literacy across the curriculum. (Integration)	3.1.1 Design and practice methods and strategies for teaching concepts and skills related to computers and related technologies including keyboarding. 3.1.2 Design and practice methods and strategies for teaching concepts and skills for applying productivity tools. 3.1.3 Design and practice methods/strategies for teaching concepts and skills for applying information access and delivery tools. 3.1.4 Design and practice methods and strategies for teaching problem solving principles and skills using technology resources. 3.1.5 Observe in a K-12 setting where K-12 computer technology concepts and skills are being taught. 3.1.6 Practice methods and strategies for teaching technology concepts and skills in a lab and classroom setting. 3.1.7 Identify and support implementation and revision of computer/technology literacy curriculum to reflect on-going changes in technology. 3.1.8 Design and implement integrated technology classroom activities that involve teaming and /or small group collaboration. 3.1.9 Identify activities and resources to support regular professional growth related to technology. 3.1.10 Describe student guidance resources, career awareness resources, and student support activities related to computing and technology. 3.1.11 Compare national K-12 computer/technology standards with	Highly recommended for all classroom instructors, site/district administration and library/media specialists. Understanding of skills by classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).

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			benchmarks set by local school districts and critique each.	
		3.1.12	Identify professional organizations and groups that support the field of educational computing and technology.	
		3.1.13	Design a set of evaluation strategies and methods that will assess the effectiveness of instructional units that integrate computers/technology.	
3.2	Candidates will demonstrate knowledge of selection, installation, management, and maintenance of the infrastructure in a classroom setting. (Basic and Advanced Technical Support))	3.2.1	Develop plans to configure computer/ technology systems and related peripherals in laboratory, classroom cluster, and other appropriate instructional arrangements.	Highly recommended for site/district administration. Highly recommended for technical support personnel (Basic and Advanced). Awareness by all classroom instructors, and library/media specialists.
		3.2.2	Identify and describe strategies to support development of school/laboratory policies, procedures, and practices related to use of computers/technology.	
		3.2.3	Research, evaluate, and develop recommendations for purchasing instructional software to support and enhance the school curriculum.	
		3.2.4	Research, evaluate, and develop recommendations for purchasing technology systems.	
		3.2.5	Design and recommend procedures for the organization, management, and security of hardware and software.	
		3.2.6	Identify strategies for troubleshooting and maintaining various hardware/software configurations.	
		3.2.7	Identify and describe network software packages used to operate a computer network system.	
		3.2.8	Configure a computer system and one or more software packages.	
4.1	Candidates will identify and apply educational and technology-related research, the psychology of learning, and instructional design principles in guiding use of computers and technology in education. (Leadership)	4.1.1	Summarize and apply principles and practices of educational research in educational technology.	Highly recommended for all classroom instructors, site/district administration and library/media specialists. Understanding of skills by classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		4.1.2	Summarize major research findings and trends related to the use of technology in education to support integration of technology in a K-12 environment.	
		4.1.3	Apply theories of learning, teaching, and instructional design and their relationship to the use of technology to support learning.	
		4.1.4	Describe social and historical foundations of education and how they relate to the use of technology in schools.	
		4.1.5	Identify research related to human and equity issues concerning the use of computers and related technologies in education.	

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	4.1.6 Design a research project that includes evaluating the use of a specific technology in a K-12 environment.	
4.2 Candidates will evaluate authoring and programming environments for use in the classroom. They will apply instructional design principles to develop, implement, and test interactive multimedia instructional products using authoring environments. (Leadership)	4.2.1 Use and apply more than one computer authoring and/or programming environment. 4.2.2 Describe the characteristics and uses of current authoring environments and evaluate their appropriateness for classroom applications. 4.2.3 Describe the characteristics and uses of current programming and scripting environments and evaluate their appropriateness for classroom use. 4.2.4 Apply instructional design principles to the design of screens, text, graphics, audio, and video in instructional products under development. 4.2.5 Describe and practice strategies for testing and evaluating instructional products designed. 4.2.6 Apply instructional design principles to develop substantive interactive multimedia computer-based instructional products.	Highly recommended for professional educators wanting to develop custom materials for use in the delivery of instruction. Understanding of skills by classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
4.3 Candidates will implement information access and delivery resources in K-12 schools to support the curriculum. (Leadership)	4.3.1 Identify and use information access and telecommunication tools to support research and instruction throughout the curriculum. 4.3.2 Use and implement distance learning delivery systems including computer, audio, and video conferencing. 4.3.3 Create multimedia presentations using advanced features of a presentation tool and deliver them using computer projection systems. 4.3.4 Install, configure, and use local mass storage devices and media to store and retrieve information and resources. 4.3.5 Describe issues related to selecting, installing, and maintaining WANs for school districts.	Highly recommended for all classroom instructors, site/district administration and library/media specialists. Understanding of skills by classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).

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4.4	Candidates will install, customize, and configure the operating systems of computers and computer networks in school settings. (Basic and Advanced Technical Support)	4.4.1	Identify and describe the major operating systems associated with computing platforms found in K-12 schools.	Highly recommended for technical support personnel (Basic and Advanced) and library/media specialists. Awareness of skills by all classroom instructors, classroom support personnel and site/district administration.
		4.4.2	Identify and manipulate preferences, defaults, and other selectable features of operating systems commonly found in K-12 schools.	
		4.4.3	Use and manipulate net-working software to effectively manage the operation of a LAN.	
		4.4.4	Evaluate, troubleshoot, install, and maintain computer operating systems for classrooms and laboratories.	
4.5	Candidates will identify and implement software in both classroom and administrative environments. They will investigate issues related to school/site planning, purchasing, and technology integration. (Leadership)	4.5.1	Identify and describe software used in classroom and administrative settings including productivity tools, information access/ telecommunications tools, multimedia/hypermedia tools, school management tools, evaluation/portfolio tools, and computer-based instruction.	Highly recommended for site/district administration and library/media specialists. Understanding of skills by all classroom instructors and classroom support personnel. Awareness of skills by technical support personnel (Basic and Advanced).
		4.5.2	Investigate and recommend purchasing strategies and procedures for acquiring administrative and instructional software for educational settings.	
		4.5.3	Describe evaluation criteria for software and identify reliable sources of software evaluations.	
		4.5.4	Identify and implement methods of installation, maintenance, inventory, and management of software libraries.	
		4.5.5	Develop and implement ethical and legal procedures for maintaining software libraries.	
		4.5.6	Identify and classify adaptive assistive hardware and software for students and teachers with special needs and locate sources to assist in procurement and implementation.	
5.1	Candidates will develop curricular plans based on local, state, and national standards for the use of computers and other associated technologies. (Leadership and Integration)	5.1.1	Describe and analyze accepted principles of strategic planning to facilitate curriculum design for teaching with computers and related technologies.	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district.
		5.1.2	Identify and use national, state, and local guidelines to develop curriculum plans for integrating technology in the K-12 environment.	
5.2	Candidates will apply effective methods and strategies for teaching the use of technology tools. (Leadership)	5.2.1	Demonstrate methods for teaching hypermedia development, scripting, and/or computer programming in a problem solving context in K-12 schools.	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district. Also, recommended for education professionals responsible for the training of other educators and/or the development of multimedia based
		5.2.2	Demonstrate methods for teaching at least one modern authoring tool to colleagues and students.	
		5.2.3	Demonstrate methods for teaching uses of media-based tools such	

ISTE Program Standard		ISTE Performance Standard Educators will.		Personnel Recommendations
			as television, audio, print media, and graphics. 5.2.4 Demonstrate methods for teaching social, ethical, and legal issues and responsible use of technology.	instructional materials.
5.3	Candidates will demonstrate knowledge of issues and models related to leadership in staff development. Candidates will plan and design staff development activities for educational settings. (Leadership)	5.3.1	Plan and design staff development programs. 5.3.2 describe and identify resources for staff development. 5.3.2 Plan and customize staff development based on differing audiences including school and district decision-makers.	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district.
5.4	Candidates will demonstrate knowledge of issues related to facilities and resource management. (Leadership)	5.4.1	Describe and use budget planning and management procedures related to educational computing and technology facilities and resources. 5.4.2 Identify funding sources available at local, state, and/or national level and collaborate on development of a grant proposal. 5.4.3 Plan, develop, implement and evaluate strategies and procedures for resource acquisition and management of technology-based systems including hardware and software. 5.4.4 Identify, describe, and analyze procedures related to basic trouble shooting, preventive maintenance, and procurement of system wide maintenance services. 5.4.5 Describe and maintain current information involving facilities planning issues related to computers and related technologies. 5.4.6 Design and develop policies and procedures concerning staffing, scheduling, and security for managing computers/technology in a variety of instructional and administrative school settings.	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district.
5.5	Candidate will demonstrate knowledge of strategies for and issues related to managing the change process in schools. (Leadership)	5.5.1	Evaluate school and district technology plans recommend improvements. 5.5.2 Discuss issues relating to building collaborations, alliances, and partnerships involving educational technology initiatives. 5.5.3 Demonstrate knowledge of effective group process skills. 5.5.4 Use evaluation findings to recommend modifications in technology implementations.	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district.

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5.6	Candidates will participate in field experiences that allow them to (1) observe the use of technology to support instruction, the management of technology resources in educational settings, and the evaluation of effectiveness of technology resources for teaching and learning; and (2) apply technology resources to support instruction in classroom settings. (Leadership)	5.6.1	Observe and compare methods and strategies used in educational technology in a variety of authentic educational settings (i.e., elementary, middle, secondary, adaptive assistive classrooms, labs).	Highly recommended for any education professional seeking an advanced degree and/or responsible for strategic as well as operational integration of technology within the curriculum for a school or school district.
		5.6.2	Develop and teach a series of lessons that apply technology resources to support instruction.	
		5.6.3	Document and assess a significant field-based activity involving experiences in instructional program development, staff development, facilities and resource management, or managing change related to technology use in schools.	
		5.6.4	Document and assess experiences in implementing a WAN or LAN with Internet connectivity.	