Technology as a Bridge to Critical Thinking and a Sustainable Economic Recovery

A White Paper Prepared by Dr. Dan Johnson

For the Future Tech Idaho Conference

October 13, 2009

Background

Fundamental shifts in technology – the internet in particular – have forever changed both the definition of and the possibilities for learning in the 21st Century. Yet after almost a decade into this new century, our use of technology as an instructional tool has done little more than perpetuate a 20th Century concept of learning – the concept of memorizing facts and algorithms.

In the 20th Century the person who could read for information, follow directions, be on-time, and work hard could provide for a family and promote the social and economic well-being of a community. Twentieth Century schools provided workers for a mass production, assembly-line society that propelled the United States into a preeminent economic and political power. Within this milieu math required only that a productive individual (except for an elite group of academics and scientists) master computation skills and apply basic mathematical algorithms – a systematic scheme for carrying out computations, usually consisting of a set of rules or steps (Nichols and Schwartz, 1999). Since learning was a matter of "remembering" key bits of information or pre-established steps, the most efficient form of education became memorization. Education was a matter of listening and reading attentively and remembering what teachers believed to be the important pieces of information. With the exception of a few brief forays into experiential learning in the 1930's and conceptual learning in the 1970's, this memorization approach to learning dominated 20th Century schools.

However, as the 20th Century drew to a close, the introduction of the internet, and later wireless internet, made it possible for any person to access information or review skills at any time from almost any place in the world. While this phenomenon did not negate the need for memory as a key aspect of learning, it did redefine the role of the teacher. Moreover, it altered the purpose and complexion of schools forever.

This paper explores an alternative to the current underutilization and potential misuse of technology as a change vehicle for math instruction for the 21st Century. At issue is more than a statement of educational philosophy or a position within the maelstrom of political debate. This issue is as decisive and morally compelling for today's education reform as was Martin Luther's 1517 declaration for reform of the Roman Church. The choice before us is a choice between schools as purveyors of the 20th Century concept of "sort-and-select" and schools that live up to the democratic principles of educating the masses to ensure equal opportunity for every citizen.

The Problem

It would be far too easy to chastise teachers and school administrators for failing to take full advantage of technology to reform math instruction. At the same time, it would be unwise to assume that the mere identification of the problem will lead to a quick sustainable resolution of the U.S. math dilemma. As the 2007 TIMSS (Trends in Mathematics and Science Study) results summarized in the chart below indicate, U.S. students currently trail students in nine other countries in math performance at the eighth grade level. While this is a vast improvement over the 1995 results where U.S. students scored worse than 24 other countries (Krooze and Johnson, 1997), these results do not bode well for the economic future of our nation.

Grade 8

2007 TIMSS Scores

Country	Average Score
TIMSS Scale Average	500
Chinese Taipei	598
Korea, Republic	597
Singapore	593
Hong Kong	572
Japan	570
Hungary	517
England	513
Russia	512
United States	508

Our response to this challenge requires more than an efficient strategy for transferring information to students. It requires a vastly different understanding of learning within a global marketplace. A review of the chart indicates that several developing Asian countries outperform U.S. eighth grade students. This finding seems to corroborate Pink's contention (2005) that the U.S. faces a mixed challenge of abundance, automation, and Asia. That is, the U.S. has become a consumer nation rather than a producing nation. We have abundance and expect it to continue even though it is being produced elsewhere.

Computers and robots are capable of performing routine binary tasks much more rapidly and less expensively than human beings can perform those same tasks. And the Asian populations are teeming with a huge labor force that is becoming more highly educated and is willing to work for less money than many U.S. workers will accept.

The problem is not that we lack the data necessary to combat our failing instructional strategies for math. The U.S. is data rich but decision poor. Never have teachers had more accessibility to data than they have today. In fact, the plethora of data is overwhelming to most teachers and learners. The issue is that while teachers have been trained to varying degrees to analyze the data, much of their energy is focused on fixing what is "wrong" with the students rather than changing instructional strategies to complement the way students learn.

As I have pointed out in *Sustaining Change in Schools* (2005) this dilemma is not attributable to a lack of data or a lack of training. It is attributable to the types of learners who follow a teaching career track. Sixty-five to seventy per cent of teachers and administrators learn best when they can approach learning as a process that is based on memorization of facts and algorithms. It should not be surprising, therefore, that they tend to teach the way they learn. They then create tests that primarily measure

knowledge of facts and algorithms. Consequently, those students who learn in this manner (approximately 45-50%) score higher on teacher made and standardized tests than do their fellow students who approach learning through experience (35-40%), through modeling people with whom they have a positive personal relationship (10-15%), or through logical analyses of key concepts (5-7%).

Enter Technology

Since the 1970's math instruction has been a common focus of computer software programs in schools. In the early years of computer-aided instruction students' access to computers was somewhat limited. But a recent article in the American Economic Journal Barrow, Markman, & Rouse (2009) report that by 2003 most U.S. schools had access to the internet and that the number of public school students per instructional computer with internet access had dropped from 12.1 in 1998 to 4.4. At the same time, research on the success of computer technology in the classroom has yielded mixed results.

Until very recently the primary focus of computer software could be described as an electronic workbook that provided immediate feedback of results to students. Many of today's math software programs provide more sophisticated methods of tracking student progress and often attempt to create student interest through games and graphics. Despite good intentions, these programs remain affixed to the notion of education as memorization through repetitive practice.

One notable exception to this approach is a web-based program developed by Dr. Woo Jung that is designed to promote conceptual understanding and mathematical thinking. This program, known as T-S Nexus or Math Without Walls, is not designed for use as a stand-alone tutor. Nor is it designed as programmed learning. Rather, Nexus is designed to assume most binary functions that have heretofore demanded huge amounts of math teachers' in-class and out-of-class time and attention. In addition to being aligned with the National Council of Teachers of Mathematics standards, the Nexus/Math Without Walls program provides the following:

- ✓ General screening instruments
- ✓ Diagnostic assessments for each major math concept from grades 5 – algebra
- ✓ System generated or teacher-generated assessments for progress monitoring
- ✓ System generated individualized assignments that adjust automatically to a students' demonstrated capacity for computation, understanding, reasoning, and problem solving
- ✓ Immediate feedback of results that include correct solutions and concept summaries for each problem in the system's 45,000 problem data-base
- ✓ Multiple reports that provide individual and class progress monitoring according to concepts or chapters within the program along with class and national comparisons of progress

Early field-testing of the Nexus program in several Colorado classrooms indicates that by using the program one-hour each week in a lab situation and requiring students to complete two out-of-class assignments each week, teachers can expect approximately a 15% increase in the number of students who score proficient or advanced on the Colorado Student Assessment Program (CSAP). [See Appendix A for a summary of findings.] What is potentially more significant, however, is that T-S Nexus/Math

Without Walls can be used to go beyond the instructional confines of memorization. If implemented with fidelity, T-S Nexus promotes critical thinking as defined by Paul and Elder (2002) "thinking about our thinking as we are thinking."

A key expectation of the Nexus program is for students to record their work for each assessment or assignment in a two-column notebook. Then following each assignment students are required to review their results and copy the correct solution for any problem they have missed in the column beside their original solution. This process allows the teacher to ask what Paul and Elder (2002a) refer to as "essential questions" that promote thinking about the following:

- ✓ purpose of an assignment (concept development)
- ✓ correct and incorrect assumptions made by the learner
- ✓ implications of these concepts for real-life problem solving
- ✓ incorporation of new data and facts into existing problem solving protocols
- ✓ inferences or judgments based on pertinent concepts
- ✓ larger-scale applications to mathematical thinking and problem solving

The obvious challenges to implementing the Nexus program include some teachers' fear of technology, their belief that they know their students better than a computer could ever know them, and the added stress of learning to use another new program. However, the more insidious challenge lies at a deeper level – the level of changing educators and parents' fundamental assumptions about learning.

When teachers learn to use Nexus effectively, the program performs most of the tasks that teachers have been trained to perform: creating, scoring, and recording student tests and assignments; providing examples and concept summaries for each problem within the 45,000 problem database; and presenting reports that inform decisions regarding grouping and differentiation of instruction. With these tasks accomplished by the system, teachers are left with the question of "what to do next." The Nexus system does not "fix" students so that they learn the way teachers teach. It identifies areas where students are either succeeding or struggling. This leaves teachers with the task of analyzing and responding to the root causes of students' struggles, a task for which few regular classroom teachers are adequately prepared and a task that is not typically an intuitive part of their instructional repertoire. Consequently, as Nexus solves one set of instructional problems, it creates a new set of far more complex problems.

Implications for Schools and Learning

Whether one believes that education involves the promotion of academic skills to enrich and sustain life-long learning or "real-world" skills that sustain a strong U.S. economy, the literature is clear that critical thinking and problem solving along with the ability to relate to people of varying values and cultural expectations will be critical skills for success in the 21st Century. Freidman (2006) describes the world as being flattened by technology and other forces so that emerging nations will be able to access education and economic power at a much faster pace than might have been possible prior to the 21st

Century. Pink (2005) as cited earlier addresses the issues of abundance, automation, and Asia with the same emphasis for changing the way we think about our world and the kinds of "intelligences" that will be required for success in this rapidly changing environment. IBM (2007) describes the necessary skills for success in the 21st Century as follows:

- ✓ Social skills to work in diverse, multi-cultural teams
- ✓ Leadership
- ✓ Adaptability
- ✓ Communications skills
- ✓ Comfort with ambiguity
- ✓ Ability to recognize patterns in disparate data/analytical skills
- ✓ Understanding how to translate challenges into opportunities

This shift is further supported by Marzano, Pickering, and Pollock's research (2001) that cites the ability to recognize similarities and differences among seemingly disparate facts as the most significant factor in promoting percentile gains on standardized tests. In many ways 21st Century learning defies the very concept of memorizing a set of facts and algorithms that remain constant across time, cultures, and situations. Unlike the 20th Century values of loyalty to a philosophy, an individual, or a company, these 21st Century skills suggest a need to move to a more opportunistic vigilance, a need to adapt to change at multiple levels, and a need to analyze rather than memorize. It is not surprising, therefore, that educators and parents struggle to adapt to this kind of change – change that Quinn (1996) described as 'deep" change at the habituated attitudinal levels of consciousness. This is the level of attitudinal adjustment that Quinn suggests is most critical for sustainable change to take place. It is probably one of the most difficult shifts required for sustaining meaningful change across time and across groups.

This is not the type of change for which people can be "trained." Instead, educators must continue to refine the concepts of cognitive coaching (Costa and Garmston, 2002) and professional learning communities (Dufour and Eaker, 1998) where educators engage in reflective review of their work. However, the assumption that bringing a diverse group of teachers, parents, and educators together under the auspices of "shared decision making" constitutes effective reflective practice is both nonsensical and dangerous. It borders on educational malpractice. Since 65-70% of educators share similar assumptions about learning and teaching (and these are the same people who have created the evaluations that determine "success" in school) these "shared decision-making" groups often do little more than create new strategies to perpetuate a 20th Century memorization and practice approach to learning. Rather than mirroring a medical postmortem analysis of data to determine why a patient died on the operating table, educational shared-decision making often mirrors a town meeting where political correctness and educational philosophy matter more than the critical analysis of data.

What we must ask, therefore, is not how we can teach students to use technology, but how we can use technology more effectively to teach students. We must avoid analyses that suggest how to change students so that they learn the way we teach. Instead, we must ask how we can change the way we teach (at a deeper, structural level) so that we reach students who learn through multiple styles and

modalities. This requires a task analysis of learning by content. For example, Levine (2002) suggests six components of skilled work in mathematics that can provide a useful rubric for identifying where students may be struggling with their mathematical thinking:

- ✓ Effective memory functions
- ✓ Accurate spatial processing
- ✓ Conceptualization
- ✓ Language ability
- ✓ Problem-solving skills
- ✓ Mathematical comfort and affinity

It is significant to note that Levine's list includes memory, but it expands learning to include several other components. Levine further suggests ways in which teachers can analyze students' underdeveloped mathematical abilities in terms of incomplete conceptualization, slow data processing, limited rule application, weak language processing, and several other areas that impede a student's progress in math. It is through an understanding of these skills and neurological functions that educators will transform their concept of learning from mere memorization and practice to a higher level of critical thinking and problem solving. It is also through an understanding of these skills and functions that educators will transform their work from the level of skilled technician to that of skilled professional.

Summary and Next Steps

As stated earlier, the U.S. faces significant educational and economic challenges as we approach the next nine decades of the 21st Century. As we entered the final quarter of the 20th Century, the futurist, Alvin Toffler (1970) described a pending period of turmoil, nostalgia, and disappointment that has accompanied every major technological change throughout the history of the world. That Toffler was correct is only the first part of his message. While he described with incredible accuracy what we have experienced during the past several decades of tumultuous change, it is important to remember the positive note upon which Toffler ended his book. In his summary he reminded us that following a series of economic, social, and psychological ups-and-downs, life improves for a much larger portion of humanity.

Rather than attempting to re-take the place of preeminent economic and military power that we enjoyed at the close of the 20th Century, perhaps the U.S. can lead a new vision of what learning and schools can become as models of ensuring success for all students. Emerging research and best practice suggest that this new vision will require a different set of instructional strategies that will, in turn, require a different school structure. The promise provided by the use of the T-S Nexus mathematics software suggests that this emerging structural change should include, but not be limited to, the following changes in educational assumptions:

- ✓ Recognizing the changing definition of learning for success in the 21st Century, a shift from memorization as an end to memory functions as one aspect of a complex set of skill components for math

- ✓ Recognizing a shift from teachers posing higher order questions to students to teachers modeling and facilitating essential questioning with students so that students can learn to pose their own higher order questions
- ✓ Recognizing a shift in focus from what students need to know to a focus on the moral and ethical responsibilities that accompany knowledge
- ✓ Recognizing a shift from the use of computers as electronic workbooks and sources of instant gratification to a use of computers as machines that can perform binary tasks in ways that free educators and parents to focus on analyzing students' thinking processes to help them bridge gaps in their learning repertoire
- ✓ Recognizing a shift away from sharing opinions and frustrations in large groups designed to fix students and parents to analyzing and acting on instructional strategies so that they address differences in students' learning styles and modalities
- ✓ Recognizing a shift from searching for a single answer (or even a single set of answers) that will improve student performance to a clinical approach to learning on an individual basis
- ✓ Recognizing a shift away from both hierarchical and "flat" organizational school structures to a concept of an educational brokerage where results (particularly a consistent pattern of results) determine temporary power within any decision-making milieu

In *Sustaining Change* (Johnson, 2005) I suggest specific procedures for building a culture based on the above assumptions. Like this list, the description in that book was not intended to be an end point but a beginning point for an exciting and enriching discussion followed by clear and decisive actions. I have been told by friends and colleagues that my book, like many of my conversations and conference presentations, are too deep or academic for most people to enjoy. My response to those admonitions remains unchanged. "I do not raise these issues to make people happy; I raise them in hopes of improving the lives of young people, specifically those of school age." It is during these early years that we develop the beliefs and attitudes that define who we are as learners and as members of society during most of the remaining years of our life.

Many well-intentioned adults spend much of our lives trying to fix kids so that they do not make the same mistakes we made. This focus on fixing implies to our children that they were created somewhat short of perfect rather than magically and wondrously unique. At the tender age of 60, I have decided that the more I try to fix myself, the less I become myself. Having recently watched my mother take control of the final act of her life –the act of dying – I have come to understand the need for personal control of the functions that define who we are as human beings – functions that include schools and learning. Effective education, as recently described to me by students in Mc Comb, Mississippi, depends on teachers who exude a joy for learning, a respect for different points-of-view, and a touch of righteous indignation that settles for nothing less than the best each student can produce at any juncture of life. This is learning that empowers. This is learning that produces well-adjusted, ethical critical thinkers who can recognize strengths in themselves and others and can partner with others to create a better world for the 21st Century and beyond.

Appendix

Sample School Data

T-S Nexus and School District A

School	Gr	% Prof and Adv			% Change		2006-07 T-S Nexus	
		2005	2006	2007	(05-06)	(06-07)	Users	Non-Users
STATE TOTALS	**6**	56	57	60	5.26	5.26		
STATE TOTALS	**7**	46	45	50	-2.17	11.11		
STATE TOTALS	**8**	44	45	46	2.27	2.22		
	Average				**1.79**	**6.20**		
DISTRICT TOTALS	**6**	57	62	66	8.77	6.45	**13.26**	**9.22**
DISTRICT TOTALS	**7**	49	49	60	0.00	22.45	**29.95**	**18.75**
DISTRICT TOTALS	**8**	47	52	52	10.64	0.00	**8.49**	**-2.99**
				Average	**6.47**	**7.67**		
2005-6 T-S Nexus Users								
C R MS	**6**	37	56	57	51.35	1.79	1.79	
C R MS	**7**	25	39	54	56.00	38.46	38.46	
S MS	**7**	59	64	75	8.47	17.19		17.19
S MS	**8**	55	57	53	3.64	-7.02		-7.02
M MS	**6**	67	83	73	23.88	-12.05		-12.05
M MS	**7**	49	63	76	28.57	20.63		20.63
M MS	**8**	52	57	68	9.62	19.30	19.30	
H MS	**8**	24	28	30	16.67	7.14		7.14
W MS	**6**	64	71	73	10.94	2.82		2.82
				Average	**23.24**			
2005-6 T-S Nexus Non-Users								
C R MS	**8**		38	43		**13.16**	13.16	
E MS	**6**	58	58	71	**0.00**	**22.41**		22.41
E MS	**7**	61	48	62	**-21.31**	**29.17**		29.17
E MS	**8**	52	50	63	**-3.85**	**26.00**		26.00
H MS	**6**	39	37	57	**-5.13**	**54.05**		54.05
H MS	**7**	22	25	33	**13.64**	**32.00**		32.00
W MS	**7**	70	57	65	**-18.57**	**14.04**		14.04
W MS	**8**	52	68	55	**30.77**	**-19.12**		-19.12
S MS	**6**	68	73	71	**7.35**	**-2.74**		-2.74
A MS	**6**	74	88	79	**18.92**	**-10.23**		-10.23
A MS	**7**	73	72	79	**-1.37**	**9.72**		9.72
A MS	**8**	67	78	72	**16.42**	**-7.69**		-7.69
L P MS	**6**	52	48	57	**-7.69**	**18.75**	18.75	
L P MS	**7**	43	34	45	**-20.93**	**32.35**	32.35	
L P MS	**8**	41	43	40	**4.88**	**-6.98**	143.8	
L MS	**6**	70	70	75	**0.00**	**7.14**		7.14
L MS	**7**	52	68	76	**30.77**	**11.76**		11.76
L MS	**8**	71	68	71	**-4.23**	**4.41**		4.41
T R MS	**6**		52	62		**19.23**	19.23	
T R MS	**7**		38	60		**57.89**	57.89	
T R MS	**8**		48	38		**-20.83**		-20.83
T P MS	**6**		73	82		**12.33**		12.33
T P MS	**7**		71	82		**15.49**		15.49
T P MS	**8**		88	82		**-6.82**		-6.82
				Average	**2.33**		**38.30**	**8.33**

T R 6th Grade Longitudinal Analysis of 2007 CSAP

Regular Class						
	Teacher A			Teacher B		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	60	60		71	71	
No of Advanced	4	4	**0.0**	3	5	**66.7**
No of Proficient	20	25	**25.0**	22	28	**27.3**
No of Partially Proficient	27	21	**-22.2**	35	27	**-22.9**
No of Unsatisfactory	9	10	**11.1**	11	11	**0.0**
# of Pro & Adv	**24**	**29**	**20.8**	**25**	**33**	**32.0**
% of Pro and Adv Students	**40.0**	**48.3**	**20.8**	**35.2**	**46.5**	**32.0**

Number of Students (% of class)	Teacher A	Teacher B
2006 Partially Proficient → 2007 Proficient	**9 (15%)**	**10 (14%)**
2006 Proficient → 2007 Advanced	**2 (3%)**	**2 (3%)**
2006 Unsatisfactory → 2007 Partially Pro or Better	**4 (7%)**	**1 (1%)**

Honors Class						
	Teacher A			Teacher B		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	34	34		28	28	
No of Advanced	12	23	**91.7**	13	19	**46.2**
No of Proficient	19	11	**-42.1**	11	8	**-27.3**
No of Partially Proficient	3	0	**-100.0**	4	1	**-75.0**
No of Unsatisfactory	0	0	**0.0**	0	0	**0.0**
# of Pro & Adv	**31**	**34**	**9.7**	**24**	**27**	**12.5**
% of Pro and Adv Students	**91.2**	**100.0**	**9.7**	**85.7**	**96.4**	**12.5**

Number of Students (% of class)	Teacher A	Teacher B
2006 Partially Proficient → 2007 Proficient	**3 (9%)**	**3 (11%)**
2006 Proficient → 2007 Advanced	**11 (32%)**	**8 (29%)**

Whole Class						
	Teacher A			Teacher B		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	94	94		99	99	
No of Advanced	16	27	**68.8**	16	24	**50.0**
No of Proficient	39	36	**-7.7**	33	36	**9.1**
No of Partially Proficient	30	21	**-30.0**	39	28	**-28.2**
No of Unsatisfactory	9	10	**11.1**	11	11	**0.0**
# of Pro & Adv	**55**	**63**	**14.5**	**49**	**60**	**22.4**
% of Pro and Adv Students	**58.5**	**67.0**	**14.5**	**49.5**	**60.6**	**22.4**

T R 7th Grade Longitudinal Analysis of 2007 CSAP

Regular Class						
	Teacher C			Teacher D		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	36	36		91	91	
No of Advanced	1	1	**0.0**	1	5	**400.0**
No of Proficient	8	13	**62.5**	12	31	**158.3**
No of Partially Proficient	23	23	**0.0**	35	45	**28.6**
No of Unsatisfactory	16	9	**-43.8**	43	10	**-76.7**
# of Pro & Adv	**9**	**14**	**55.6**	**13**	**36**	**176.9**
% of Pro and Adv Students	**25.0**	**38.9**	**55.6**	**14.3**	**39.6**	**176.9**

Number of Students (% of class)	**Teacher C**	**Teacher D**
2006 Partially Proficient → 2007 Proficient	**5 (14%)**	**23 (25%)**
2006 Proficient → 2007 Advanced	**1 (<1%)**	**5 (5%)**
2006 Unsatisfactory → 2007 Partially Pro or Better	**5 (14%)**	**25 (27%)**

Honors Class						
	Teacher C			Teacher D		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	19	19		29	29	
No of Advanced	4	8	**100.0**	12	21	**75.0**
No of Proficient	9	9	**0.0**	12	6	**-50.0**
No of Partially Proficient	6	2	**-66.7**	3	2	**-33.3**
No of Unsatisfactory				1	0	**-100.0**
# of Pro & Adv	**13**	**17**	**30.8**	**24**	**27**	**12.5**
% of Pro and Adv Students	**68.4**	**89.5**	**30.8**	**82.8**	**93.1**	**12.5**

Number of Students (% of class)	**Teacher C**	**Teacher D**
2006 Partially Proficient → 2007 Proficient	**5 (26%)**	**1 (3%)**
2006 Proficient → 2007 Advanced	**5 (26%)**	**10 (34%)**
2006 Unsatisfactory → 2007 Partially Pro or Better	**0 (0%)**	**2 (NA)**

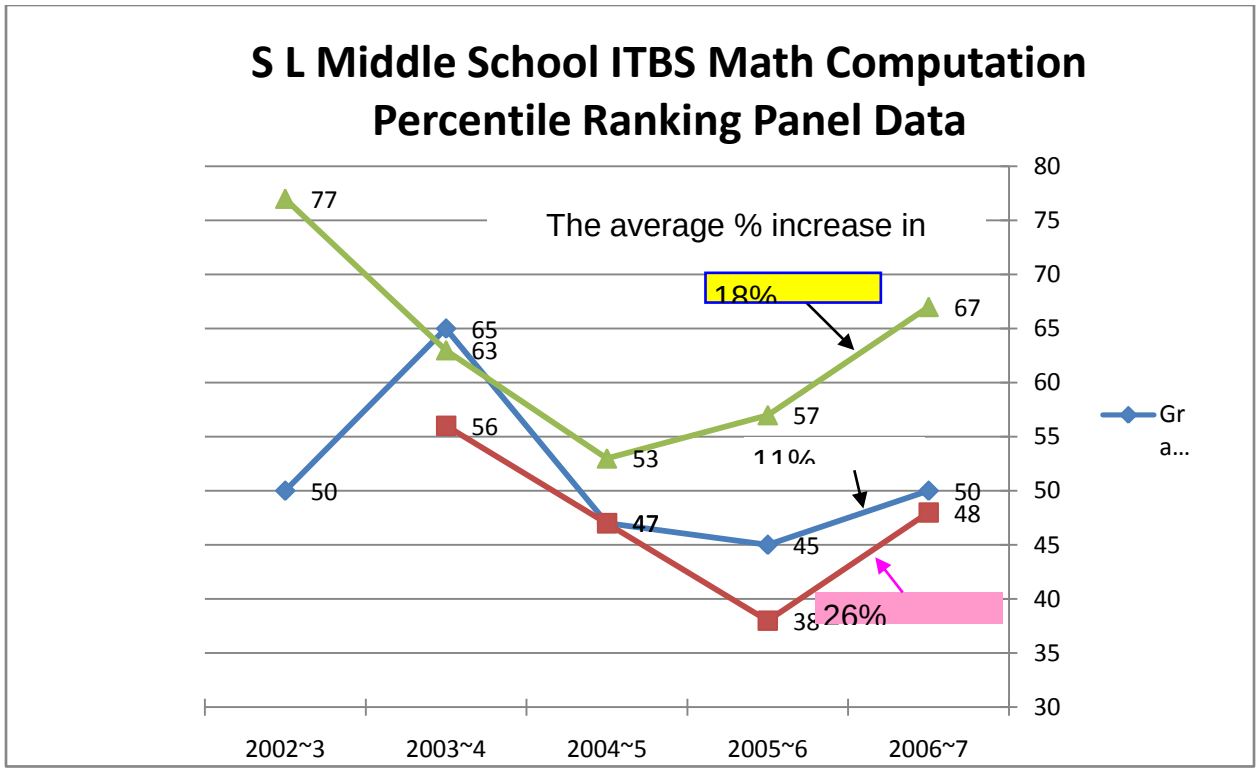
Whole Class						
	Teacher C			Teacher D		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	55	55		120	120	
No of Advanced	5	9	**80.0**	13	26	**100.0**
No of Proficient	17	22	**29.4**	24	37	**54.2**
No of Partially Proficient	29	25	**-13.8**	38	47	**23.7**
No of Unsatisfactory	16	9	**-43.8**	44	10	**-77.3**
# of Pro & Adv	**22**	**31**	**40.9**	**37**	**63**	**70.3**
% of Pro and Adv Students	**40.0**	**56.4**	**40.9**	**30.8**	**52.5**	**70.3**

L P 8th Grade Longitudinal Analysis of 2007 CSAP

	Honors Class			Regular Class		
Number of Students	**2006**	**2007**	**% Change**	**2006**	**2007**	**% Change**
Total Number of Students	31	31		43	43	
No of Advanced	6	9	**50.0**	0	2	**NA**
No of Proficient	5	15	**200.0**	5	13	**160.0**
No of Partially Proficient	20	7	**-65.0**	17	23	**35.3**
No of Unsatisfactory	0	0	**NA**	22	5	**-77.3**
# of Pro & Adv	**9**	**14**	**55.6**	**5**	**15**	**200.0**
% of Pro and Adv Students	**29.0**	**45.2**	**55.6**	**11.6**	**34.9**	**200.0**

Number of Students (% of class)	**Honors**	**Regular**
2006 Partially Proficient → 2007 Proficient	**9 (29%)**	**7 (16%)**
2006 Proficient → 2007 Advanced	**3 (10%)**	**2 (5%)**
2006 Unsatisfactory → 2007 Partially Pro or Bett	**0 (0%)**	**16 (37%)**

Whole Class			
Number of Students	**2006**	**2007**	**% Change**
Total Number of Students	74	74	
No of Advanced	6	11	**83.3**
No of Proficient	10	28	**180.0**
No of Partially Proficient	37	30	**-18.9**
No of Unsatisfactory	22	5	**-72.3**
# of Pro & Adv	**16**	**39**	**143.8**
% of Pro and Adv Students	**21.6**	**52.7**	**143.8**


S L Middle School ITBS Math Computation
Percentile Ranking Panel Data
The average % increase in
18%
11%
26%
77
65
63
56
53
57
67
50
47
45
50
48
38
80
75
70
65
60
55
50
45
40
35
30
2002~3
2003~4
2004~5
2005~6
2006~7
Gr
a...

References

Barrow, L, Markman, L, & Rouse, C. (2009). "Technology's Edge: The Educational Benefits of Computer-Aided Instruction," American Economic Journal, 1:1, pp. 52-74.

Costa, A & Garmston, R. (2002). *Cognitive coaching: A foundation for renaissance s. Norwood, MA: Christopher Gordon.*

Dufour, R. & Eaker, R. (1998). *Professional learning communities at work: Best practices for enhancing student achievement*. Bloomington, IN: Solution Tree Books.

Friedman, T. (2006). *The world is flat: A brief history of the twenty-first century*. New York: Farar.

IBM (2007). Presentation made to the Thompson School District.

Johnson, D. (2005). *Sustaining change in schools: How to overcome differences and focus on quality.* Alexandria, VA: Association for supervision and curriculum development.

Krooze, D. & Johnson, D. (1997) *Achieving excellence: A report of initial findings from the Third International Mathematics and Science Study*. Northbrook, IL.: First in the World Consortium.

Levine, M. (2002). *Educational care.* Cambridge: Educators Publishing service.

Marzano, R., Pickering, D., & Pollock, J. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and curriculum development, 2

Nichols, E. & Schwartz, S. (1999). *Mathematics dictionary and handbook.* Honesdale, PA: Nichols Schwartz Publishing.

Paul, R. & Elder, L. (2002). *Critical thinking: Tools for taking charge of your professional and personal life.* Upper Saddle River, NJ: Prentice Hall.

Paul, R. & Elder, L. (2002a *). A miniature guide to the art of asking essential questions. Dillon Beach, CA:* The Foundation for Critical Thinking.

*Pink, D. (*2005). *A whole new mind: Why right-brainers will rule the future.* New York: Riverhead Books.

Toffler, A. (1970). *Future shock.* New York: Random House.