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Technology integration into the elementary school curriculum

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A new generation of students born after 1985 – the Net Generation or Digital Natives – is now entering public schools. Historical overview shows the picture of growing computer use by children in homes and in schools for the past 10 years. ICT (Information and Communication Technologies) literacy skills and tools help students to acquire the skills needed to use the technologies within the classroom. National Educational Technology Standards (NETS) and NETS performance indicators provide guidelines for teachers of what students should know and be able to do with technologies by the end of every grade level.

This paper describes the ideas of various authors on how to integrate computer technologies into the elementary school curriculum and to overcome barriers of technology integration. The paper finishes with conclusions and recommendations for the integration of technology in schools.

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Abstract

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Introduction

A new generation of children is entering present day schools. Many teachers consider these students to be different from the ones they had before in classes. They do not meet the teacher's expectations. Teachers complain about the short attention spans and loss of interest for the curriculum that students show during lessons. Many researchers object to that, saying that students "certainly don't have short attention spans for their games, movies, music, or Internet surfing. More and more, they just don't tolerate the old ways – and they are enraged we are not doing better by them" (Prensky, 2005, p. 64). New students need a completely new approach in learning.

One of the biggest problems of elementary schools nowadays is catching the attention of Digital Natives and making the learning process interesting for them. The gap between students and teachers does not let mutual understanding happen. On the one hand, students tend to do things faster when working with digital technologies; on the other hand, teachers feel uncertain about using technology in the classroom and meeting their students' needs. It is not an easy task to help teachers realize the benefits of computer integrated curriculum at school and to build their self-confidence in using software during the lessons that will motivate their students to learn and develop their higher-order thinking skills.

> "Sure they have short attention spans – for the old ways of learning", says professor Westhead. Their attention spans are not short for games, for example, or for anything else that actually interests them. As a result of their experiences Digital Natives crave interactivity – an immediate response to their each and every action. Traditional schooling provides very little of this compared to the rest of their world (one study showed that students in class get to ask a question every 10 hours). So it generally isn't that Digital Natives can't pay attention, it's that they choose not to. (Prensky, 2001, p. 4)

The new classroom will have students explaining to their teachers and peers how to use technology. This is the process of mutual teaching, an endless process that determines the future of our schools.

Net Generation Students

Many researchers, such as Prensky (2001a, 2001b, 2005), Tyler (2007), and Smith (1998) started talking about the new generation of children who are completely different from the ones that schools had previously. Who are those Millennials? When did they appear? Why are they called Net Generation, Millennials, or Digital Natives? How do they differ from the students who teachers used to teach, and what is the great challenge of teaching this new generation of kids in the present day schools?

Definition

Various authors tried to define Millennials: according to Smith (1998), the Net Generation is presented by children who were surrounded by PCs, CD-ROMs and Internet access at home since their birth; Tyler (2007) explained:

> So-called millennial generation, now ages 8 to 29. This group, also called generation Y and the Net Generation, is made up of 80 million people in the United States born between 1978 and 1999. They are the first generation to use e-mail, instant messaging (IM) and cell phones since childhood and adolescence. (p. 1)

Prensky (2001a) tried to clarify why the best name for the new generation of students is Digital Natives. He called them "'native speakers' of the digital language of computers, video games and the Internet" (Prensky, 2001a, p. 1). People in the United States, born earlier than in 1978, are classified by Prensky as the *Digital Immigrants*. The author distinguished between the Digital Natives' and Digital Immigrants' attitudes towards

technology and their ability to use computers and the Internet. He spoke about the *accent* that all the older generation people have when using digital technology (Prensky, 2001a).

Several ideas about the degree of comfort of the Net Generation students in present day schools can be already emphasized: first, there is a certain gap between older and younger people; within schools, teachers and students represent these two generations. Following, public schools face a problem of teachers' misunderstanding of Millennial's abilities and of the ways they acquire new information, which does not fit the traditional school curriculum. Later, the problem of Millennials feeling bored in schools will be discussed. It is better to discuss the specific features of the Net Generation students first.

Specific Features of the Net Generation Students

One of the questions that have been catching the attention of many researchers and teachers is about the specific features that Millennials have and that previous generations of students did not possess. All of them agree "today's students think and process information fundamentally differently from their predecessors" (Prensky, 2001a, p. 1). Prensky (2001a) attributed the reasons for such great differences to the environment in which Millennials were born, grew, and received input. On the basis of neurobiology, social psychology, and from the studies done on children using games for learning, the researcher provided the readers with the evidence of how the digital environment influences the perception of different subjects by the Digital Natives:

> For example, thinking skills enhanced by repeated exposure to computer games and other digital media include reading visual images as representations of three-dimensional space (representational competence), multidimensional visual-spatial skills, mental maps, "mental paper folding" (i.e. picturing the results of various origami-like folds in your mind without actually doing them), "inductive discovery" (i.e. making observations, formulating hypotheses and figuring out the rules governing the behavior of the dynamic representation), "attention deployment" (such

> as monitoring multiple locations simultaneously), and responding faster to expected and unexpected stimuli. (Prensky, 2001b, p. 4)

All these cognitive skills have been known for a long time and were used by many generations of students. So, what is new about Millennials?

Prensky (2001b) stressed that the reason for Millennial's differences is not in the skills, but in their combination and intensity. That is why, thanks to the Internet access and digital equipment, the Net Generation kids seem to work faster. Multimedia includes all the senses in their learning process, and they are more flexible due to the constantly changing environment. Prensky (2001b) also emphasized that there are curricula components that need increased attention. In the case of the Digital Natives, reflection and critical thinking must be taught through instruction.

Millennial's special language of interaction and conditions for successful learning are different from traditional classroom environments. Tyler (2007) indicated, "90 percent of 18-to-24-year-olds feel that listening to an iPod while working improves their job satisfaction and productivity" (p. 1). Supported by her study on the role of media in the lives of 8-18 year-olds, the author explained why Millennials are not satisfied with the old ways of teaching and learning at school. They need constant stimuli and are bored when their brains are not busy working with the demanded amount of coming information. Teachers have to understand the environment in which their students grow to better know their needs and be able to minimize the existing gap between the Digital Natives and Digital Immigrants (Tyler, 2007).

Digital Natives and Their Environment

Digital Natives are not just a new generation. They are also a new *nation* with its own culture, perception of reality, and language. Its country is the World Wide Web (WWW) that

makes no distinction between geographical countries and nationalities. Its only limitation is age. Prensky (2001b) pointed out, "People who grow up in different cultures do not just think about different things, they actually think differently. The environment and culture, in which people are raised affects and even determines many of their thought processes" (p. 3). The digital environment formed the Millennial's perception of the world around them.

Many readers still remember playing games outdoors most of the time and spending few hours in front of the first black and white TVs. It was a common thing to visit each other or to leave a message on the door or table, and have to guess whether the person it was written for read this note or not. Tyler (2007) pointed out, "The majority of Millennials never experienced life without a microwave, computer, and ATM card or television remote control. Many had their cell phones in their early teens with parents footing the bill" (p. 3). These kids do not like to wait or be unaware of something. They prefer to have several tasks being done at the same time. They use digital electronics to process huge amounts of information at a high speed.

> Children raised with the computer think differently from the rest of us. They develop hypertext minds. They leap around. It's as though their cognitive structures were parallel, not sequential. Linear thought processes that dominate educational systems now can actually retard learning for brains developed through game and web-surfing processes on the computer. (Prensky, 2001b, p. 4)

Teachers may find it difficult to understand the way the Digital Natives think over one problem and start operating information for solving the other one at the same time, not as in a step-by-step model.

Being a Millennial, as well as being any other person, has its advantages and challenges. According to Tyler (2007), positive sides of the Net Generation are being multitaskers, techno-savvy, adept at global and diversity issues, and team-oriented. Being

multitaskers, Millennials are able to work on several tasks at the same time. Such kids, for example, will be writing a composition, watching TV, listening to the iPod, checking e-mail, chatting on-line, and talking over the phone at the same moment. Otherwise, writing a composition can be challenging for them.

Knowing technology very well, Net Generation students can find the information they need much faster than any teacher or adult. Collective work adds to the speed of getting and processing the information significantly. Millennials work in teams. They exchange information, learn the news, and make collective decisions, working as millions of cells of a huge brain. They make no difference between nations, languages, or skin color, because they can change their appearances and names in the digital world. The only division they make is whether someone can speak the digital language or not, possesses the necessary skills for communication and work or tries to make them do things in an old, slow, and boring way for them. Digital Natives are "accustomed to the twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of their video games, MTV, and Internet are bored by most of today's education, well meaning as it may be" (Prensky, 2001b, p. 5). The Net Generation students expect teachers to speak the new language of the digital technologies.

Millennials need special treatment. But before taking a closer look at how teachers should prepare for the Net Generation, it is important to point out some challenges that present day schools might have when working with Digital Natives.

On the base of her study about influence of media on the lives of 8-18 year-olds Tyler (2007) stated, the new generation lacks discretion, independence, realistic expectations, patience, work ethic, and the basic skills. Millennials do not divide private and public issues.

Being multitaskers, they do everything at the same moment, making no difference of what is appropriate at that moment in a certain place. Good team workers, nevertheless, are not able to make an independent decision. Net Generation kids would discuss the problem with the whole group and give a collective solution. As they spend their time in cyberspace, they get used to the great speed of information exchange and become intolerant of time-consuming processes. New generation children do not like to wait for anything or anyone. If they fail doing one task, they would drop it, showing no persistence and willingness in completing it.

That is why it is really hard for Millennials to have realistic expectations towards the work they do: their expectations would be always high, and the results should show up immediately. Showing proficiency in the digital world, Digital Natives lack interpersonal skills, because they never meet with each other and even hardly know each other's real appearances or names. Teachers should keep in mind all these characteristics of Millennials while working with them at school.

How to Prepare for the Millennials

Knowing the strengths and the weaknesses of Millennials, teachers will be able to prepare for the new students in their class by:

1. Increasing basic skills training
2. Explaining the reasons behind processes
3. Placing clear parameters on communication frequency and methods
4. Providing more frequent job performance appraisals and other feedback
5. Focusing on outcomes
6. Keeping them engaged
7. Expanding life/work balance programs (Tyler, 2007).

There is a concern about how to approach Digital Natives. Prensky (2001a) accentuated, "The single biggest problem facing education today is that our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language" (p. 2). He suggested effective ways of teaching the Digital Natives by introducing computers and video games to them (Prensky, 2001b).

Taking into consideration all this information about Millennials, teachers just need to be able to change their old ways of teaching and adjust them to the new reality so that new generations of students feel more comfortable learning at school.

Methodology

Various articles written between 1998-2007 were examined in order to find out the answers to the following questions: How often have computers been involved in classrooms in the past 10 years? What barriers do schools meet in the process of technology integration into the school curriculum? How does that situation influence teacher and student's attitudes towards the innovations? How is technology integration reflected in the National Educational Technology Standards (NETS) and in the NETS performance indicators in classes Pre-K through 6? What are the ways to introduce technology to teachers and students? What is the possible future development of technologies in schools? Answers to these questions helped to build a picture of the most recent changes in the elementary schools.

Literature Review

Historical Overview of Using Computers in the Classroom

The purpose of this section is to show how significantly the numbers and the quality of computers in public schools grew in the past several decades, and to describe the growing

role of technologies as teaching and learning tools since the new generation of technology-savvy students entered American schools.

The history of computer use in schools started in the second half of the twentieth century. Microcomputers have been in schools since 1978 (Roblyer, 2000). The number and the quality of computers have greatly improved since 1978. Computers started being used in elementary classrooms in the 1990s. Smerdon et al. (2000) in their report on teachers' use of technology gave the numbers of computer use in elementary classrooms in 1990 and compare them with the data collected in 1998. In 1990, 7% of 4th grade classrooms didn't have computers at all, and only 1% of elementary schools could afford 76 or more computers; in 1998, there were already 33% of elementary schools that had 76 or more computers. The Net Generation now is impressive by the amount and speed of using digital supplies. Prensky (2001b) addressed the technology use by the Net Generation in overwhelming numbers:

> Over 10,000 hours playing videogames, over 200,000 emails and instant messages sent and received; over 10,000 hours talking on digital cell phones; over 20,000 hours watching TV (a high percentage fast speed MTV), over 500,000 commercials seen – all before the kids leave college, and, maybe, at the very most, 5,000 hours of book reading. (p. 1)

The US government realized the need for developing and mastering the new technologies both by students and teachers. That is why "over the past 10 years the United States has spent more than $19 billion on developing information technology infrastructures in local school districts and classrooms" (Slowenski, 2001, cited in Wilson, Notar, & Yunker, 2003, p. 258). Other sources emphasized changes in numbers of computers per student within several years and Internet availability for public schools:

> Nationwide, the ratio of students per computer has fallen from an average of 10.1 in 1995 to 5.4 in 1999-2000 (Quality Education Data, 2001, cited Barron, Kemker,

> Harmes, & Kalayfjian, 2003, p. 489). The percentage of public schools that have Internet access has increased from 35% (1994) to 99% (2002), and the percentage of public classrooms connected to the Internet has risen from 3% in 1994 to 87% in 2001. (Kleiner & Farris, 2002, cited in Barron, Kemker, Harmes, & Kalayfjian, 2003, p. 489)

These changes also touched upon the elementary school level, and "today, 99% of public elementary schools and 86% of elementary instructional rooms have access to the Internet" (Franklin, 2007, p. 268).

However, just computer and Internet accessibility do not mean that there is technology integration in the school curriculum. Elementary school students frequently use computers only for training and playing educational games, rather than for creating things. Berg, Benz, Lasley II, & Raisch (1998) claimed, in 1995 computers were mostly used for basic-skills practice. Lack of training provided for teachers, influences their attitude towards the use of technology in the classroom. In 1999 "only 20% of the 2.5 million public school teachers feel comfortable using computers in the classroom" (Collier, Weinburg, & Rivera, 2004, p. 448). Schools are still being provided with computers, but teachers resist using them for educational purposes.

In the quantitative study that investigated the use of computers in the classroom by elementary teachers and students and that was conducted by Wilson, Notar, & Yunker (2003) found, "The way our students in elementary level classrooms are being taught in the year 2003, has not changed significantly from 1990" (p. 256). First, students are not allowed to spend enough time on the computer. "The elementary students averaged 1.5 hours a week on the computer, with that time spent either on the Internet or using a CD for instruction/remediation or to play games"(p. 261). Second, as stated by Wilson, Notar, & Yunker (2003), teachers are not yet actively integrating technology into the elementary

school curriculum: teachers on average spend 1.9 hours per week on the computer mostly searching for the instructional materials; and teachers allow students to use the computer after the work has been completed usually as a reward for the classroom behavior.

Technology integration into the school curriculum has a long history. It combines the processes of software development and computer extension in schools and people's homes. This raises the questions of technology training both for adults and children and financial matters. Modern schools are on their way to overcoming these difficulties and building a new technology friendly community of the 21st century learner.

National Educational Technology Standards

National Educational Technology Standards (NETS) were developed after the term Information and Communication Technologies (ICT) appeared. ICT is about being computer literate and possessing *computer literacy skills*. ICT suggest tools that will help students acquire technologies. National Educational Technology Standards (NETS) and performance indicators describe students' skills and volume of knowledge about the use of technologies at each grade level.

Because of advancing technology, government officials wished to find ways to connect education and developing computer technologies. Arthur Luermann was the first to mention the term *computer literacy* in pre-microcomputer days, i.e. before 1978 (Roblyer, 2000).

ICT literacy is basically about learning *new stuff* and "learning new ways to do *old stuff*" (Prensky, 2001a, p. 4). As indicated by Prensky (2001a), it consists of two parts: methodology and content. According to methodology ideas, teachers have to start communication in Digital Natives' language in schools and make learning more parallel and

less step-by-step. The content can be divided into *legacy* content, in other words traditional curriculum, which includes reading, writing, arithmetic, logical thinking, and understanding the ideas of the previous generations; and *future* content that is "digital and technological" and includes software, hardware, robotics, nanotechnology, genomics as well as the ethics, politics, sociology, and languages (Prensky, 2001a, p. 4).

Several authors distinguished six "areas of technology competence" that include the following ICT (Information and Communication Technologies) tools:

1. *Basic operations and concepts* help students to demonstrate a basic understanding of technology, such as computers, televisions, VCRs, and audio tape players. Students are proficient in the use of computer terminology, proper care of the monitor, and selection of a printer.
2. *Social, Ethical, and Human Issues* include the topics involving the use of technology. Students demonstrate their ability to evaluate media images and to make responsible choices about what they see and hear.
3. *Technology Productivity Tools* help students to use various forms of technology to create media such as documents, movies, pictures, and spreadsheets. Students properly use an assortment of hardware, such as probes, scanners, and digital cameras to construct their knowledge.
4. *Technology Communication Tools* help students to use media to interact with peers, experts, and other audiences. Students are able to collaborate, communicate, and interact effectively with the range of audiences for both directed and independent learning.

5. *Technology Research Tools* help students to use technology as a tool to locate, evaluate, and collect information from a variety of sources. Students are proficient in evaluating the accuracy, relevance, appropriateness, comprehensiveness, and bias of online information.
6. *Technology Problem-Solving and Decision-Making Tools* refers to contents where technology is used to develop strategies for recognizing and solving problems. Students are able to identify a problem, determine if technology is useful in solving the problem, and if so, select and implement the appropriate tools. (Niederhauser, Lindstrom, & Strobel, 2007; Roblyer, 2000; Barron, Kemker, Harmes, & Kalaydjian, 2003)

Based on the case study of an elementary school in Singapore that described how different types of ICT tools were used to engage students in high-order thinking, Lim and Tay (2003) classified ICT tools into four categories taking into consideration not only their characteristics but also how these tools were used during the lesson:

1. *Informative tools* provide information in text, sound, graphics, or video
2. *Situating tools* are the systems that situate students in an environment where they may *experience* the context and happenings
3. *Constructive tools* are used for manipulating information and constructing student's knowledge
4. *Communicative tools* help communication beyond the physical barrier such as space or time to happen.

Standards for computer and technology use or for *technology literacy skills* were developed for teachers and students. "ISTE [International Society for Technology in

Education] worked in conjunction with the National Council for the Accreditation of Teacher Education (NCATE) to generate standards and a vision statement for how teacher education programs should address technology" (Roblyer, 2000, p. 135). The result of this collaboration was creation of the National Educational Technology Standards.

The National Educational Technology Standards and performance indicators that were created both for teachers and students to inform them of what they are supposed to know and be able to do at a certain grade level. "When students are able to choose and use technology tools to help themselves obtain information, analyze, synthesize, and assimilate it, and then present it in an acceptable manner, then technology integration has taken place" (U.S. Department of Education, 2002, p. 79). Becker (1994) used national survey data to find out how exemplary teachers worked with computers. On the basis of this research, he suggested how to use computers as a tool for effective learning where "students grow intellectually and not merely develop isolated skills" (p. 294, cited in Berg, Benz, Lasley II, & Raisch, 1998, p. 2). National Educational Technology Standards for Students include baseline standards with performance indicators for all students from pre-K to 12th grade. They also include examples of subject projects that use hardware, software, books, and Web sites. NETS and performance indicators are described in Appendixes A and B.

The necessity of having the NETS both for teachers and students was dictated by the increasing numbers of computers in schools and at homes. The next step is to integrate computer technologies into the elementary school's system on the basis of the existing technology standards.

Integration of Computer Technologies into the Elementary School Curriculum

Computer integration into the elementary school curriculum is supported by several facts: it is beneficial both for teachers and students, and it helps to develop students' higher-order thinking skills. The process itself includes alignment with the school's curriculum, teacher leadership, availability and access to technology, public/private roles for technology recognition, and teacher preparation and training. The following section will describe the benefits of teaching technology-integrated lessons to elementary school children in present day schools.

Benefits of Teaching Elementary Students with Technology

Using technology with today's elementary students (Millennials) has educational benefits in the educational process. On the word of Staples, Pugach, & Himes (2005), who documented technology integration into the curricula of the three urban schools, "instructional leadership, extensive professional development, a whole-language approach to learning, establishment of libraries, de-emphasis on remediation, and emphasis on fostering student creativity" are necessary "to maximize the effect of technology on student learning" (p. 287). Hruskocy, Cennamo, Ertmer, & Johnson (2000) believed that if students in the class work collaboratively and support each other, motivation to study increases and students tend to work independently. The learning becomes self-directed; all students try leadership in group-projects and show respect to each other. Hruskocy, Cennamo, Ertmer, & Johnson (2000) underlined learning "about learning in addition to learning about technology" (p. 79).

Pan and Carroll (2002) conducted a qualitative study to find the ways for teachers to successfully acquire technology skills and integrate technology into the elementary school curriculum and noticed the ability of the Net Generation students to be multitaskers and get

interested only when all their senses are engaged. "The computer through its use of text, sound, graphics, animation, and multimedia control, is ideally suited to present such a rich environment" (Pan and Carroll, 2002, p. 372). Hruskocy, Cennamo, Ertmer, & Johnson (2000) gave an example of student learning with the integrated technology:

> Classes searched the library browser to locate books and searched CD-ROM resources to collect information. They typed reports using the word processor, created illustrations with drawing and paint programs, captured graphics from electronic sources, and created XapShot images. Student groups created projects on a variety of topics such as dinosaurs, fairy tales, and the 50 states... Using Hyper Studio, students learned to create cards, buttons, and links incorporating text, graphics, and sound. (p. 76)

Technology is a helpful tool for creating school projects and expanding student's knowledge about the subject. The other beneficial factor for teachers and schools is that teachers are motivated to integrate technologies into their every day teaching by their students' success (Hruskocy, Cennamo, Ertmer, & Johnson, 2000).

To summarize, technology integration benefits schools in the following ways: elementary school teachers and students are more motivated to learn and use technology; teachers implement more technology-use in class; students are more self-directed learners; they feel more comfortable with technology, learn new way of learning, and learn the value of collaboration. (Hruskocy, Cennamo, Ertmer, & Johnson, 2000)

Hruskocy, Cennamo, Ertmer, & Johnson (2000) developed the idea of having Tech (Technology) Days that "allow students to become comfortable using computers and to discover the many things that can be done with computers" (p. 79).

Pan and Carroll (2002) created the Magic School Bus project that helped them to make an observation of software use by elementary school children. They found out that the CD-ROM gives children an opportunity to learn independently and explore things on their

own; children tried to avoid difficult activities that included a lot of information; and that "younger children liked the software more than older ones and were excited by the sights and sounds they were able to create, only a few children took an interest in the long-range game-like activities that the CD-ROMs included, children were generally good at sharing the mouse and working together" (Pan, & Carroll, 2002, p. 376).

These studies explain that computers work as teaching tools when they meet the development peculiarities and needs of the elementary school children. The younger the students are, the more they are willing to use computer programs because of the sound, moving pictures, and bright colors. Children have short attention spans for activities that are too advanced for their age level, and need clear instructions of how to use a computer as a tool in their work. Moreover, students can work collaboratively.

Pan and Carroll (2002) identified the following benefits of computer use in the classroom:

1. Has informational value
2. Can give the teacher instructional ideas
3. Expands children's horizons
4. Allows children to explore new learning concepts
5. Engages children in learning in a fun, exciting way
6. Stimulates the senses and allows children to express their creativity
7. Provides physical participation that keeps children focused
8. Provides a relief from lecture-style and other traditional teaching methods
9. Gives children choices and allows them to take control of their own learning
10. Is valuable because children like it

11. Builds confidence

12. Inspires children to use computers, so that they develop skills for the future.

Hopson, Simms, & Knezek (2001-2002) examined the effect of technology-enriched classrooms on student development of higher-order thinking skills and students' attitudes towards technology, and came to a conclusion that the skills that children can use in the future, such as problem solving, active learning, authentic tasks, challenging work, complex problem solving, critical thinking, and higher-order thinking are acquired faster and work more effectively when technologies are used as learning tools.

> Higher-order thinking skills are acquired when learners construct knowledge rather than passively ingest information, sophisticated information-gathering tools are used to stimulate the learner to focus on testing hypotheses rather than on plotting data, there is collaborative interaction with peers, similar to team-based approaches underlying today's science, and evaluation systems measure complex, higher-order skills rather than simple recall of facts. (Hopson, Simms, & Knezek, 2001-2002, p. 110)

According to Hopson, Simms, & Knezek (2001-2002), higher-order thinking skills include operations of analyzing, criticizing, cross-referencing, and transforming the information into usable knowledge.

Lim and Tay (2003) in their case study about the role of the ICT (Information and Communication Technologies) in development of higher-order thinking skills in elementary classrooms found a connection between the types of ICT tools and student engagement in higher-order thinking. Gagne, Brigs, & Wager (1992) in the work "Principals of Instructional Design" grouped all the learning skills outcomes in categories, such as verbal skills; intellectual skills, which are subdivided into "discriminations, concrete concepts, defined concepts, rules, higher-order rules – problem solving"; cognitive strategies; attitudes; and motor skills (cited in Lim, & Tay, 2003, p. 427).

The Process of Computer Integration into the School Curriculum

As it was mentioned previously, constantly developing technologies have influenced the way school programs are run. Teachers today have more opportunities to use technology tools in schools. However, computer-integrated technology in United States schools is only starting to develop and is not yet used to its full state. Staples, Pugach, Himes (2005) from the case study of computer integration into the curricula of the three urban schools and Franklin (2007) in the research about the factors that influence the use of computers by elementary teachers suggested the following scaffolds to support technology integration: alignment with the school's curriculum, teacher leadership, availability and access to technology, public/private roles for technology recognition, and teacher preparation and training. The first four scaffolds will be discussed in this chapter, and the teacher preparation will be explored later.

Alignment with the school curriculum. Many teachers and educators feel frustrated because they don't know how to find the right approach for the new students. Net Generation kids work with a large amount of information and they are able to memorize many facts if they are interested in them. For example,

> In geography – which is all but ignored these days – there is no reason that a generation that can memorize over 100 Pokemon characters with all their characteristics, history and evolution can't learn the names, populations, capitals and relationships of all the 101 nations in the world. It just depends on how it is presented. (Prensky, 2001a, p. 5)

Motivation is a great issue in teaching Millennials. Prensky (2001b) is persuaded that computer games can motivate students to practice skills because attract attention with sound, motion and bright pictures. There is also a concern for using really educative games and programs that would raise the quality of education. From the case study of the two lessons

with ICT (Information and Communication Technologies) integration, Goodison (2003) gave outlines for the general teaching and learning principles and adds some ideas on exploiting technology. They include the following general principles:

1. Teachers must draw out and work with the pre-existing understandings that their students bring with them.
2. Teacher must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual knowledge.
3. The teaching of metacognitive skills should be integrated into the curriculum in a variety of subject areas (Godison, 2003).

Goodison (2003) added three principles of exploiting technology that are based on the general methods and serve as an addition to them. They include bringing exciting curricula based on real-world problems into the classroom; providing scaffolding and tools to enhance learning; and giving students and teachers more opportunities for feedback, reflection, and revision.

Berg, Benz, Lasley II, & Raisch (1998) summarized all the ideas and concerns about the importance of technology-integrated curriculum in elementary schools of southwestern Ohio and came up with the suggestions for the instructional planning. According to them, teachers and educators can change from a traditional classroom to one that motivates students, be more creative in designing assignments, tailor curriculum to individual needs, use integrated subject matter and criterion-referenced assessment/portfolios, and provide students with collaborative work in a more productive way when using computer technologies as teaching and learning tools (Berg, Benz, Lasley II, & Raisch, 1998). Roblyer (2000) in the survey of historical and current context for the NETS (National Technology

Educational Standards) presented some technology-integrated lesson ideas for each grade level, which are described in Appendix C.

Teacher leadership. The changes in the curriculum can take place only if teachers are willing to act. Smith (1998) in the study of the teacher preparedness for the Net Generation students assumed, it is up to teachers to what extent to integrate technology into the curriculum. Teachers must be provided with "opportunities and resources they need to integrate technology in the classroom and the curriculum to manage and monitor its use" (Smith, 1998, p. 2). Teachers are very close to students and know their needs and peculiarities. No one can find a better approach to students. Staples, Pugach, & Himes (2005) emphasized that this makes teachers responsible for the frequency and depth of computer use in their classrooms and for resources they choose. The principal at Rosa Parks urban school and many other principals, see more sense in hiring the technology-savvy staff without looking for just technology specialists, which saves the budget for other school needs (Staples, Pugach, & Himes, 2005, p. 303).

Smith (1998) expected technology-friendly teachers to be also good because of the student's growing self-esteem and attitude towards the learning process. Children are interested in working with computers, which can serve as the richest source for their motivation. Besides, "teachers' professional and personal growth can have a powerful, positive effect on students' self-confidence, skills development and classroom behavior" (Smith, 1998, p. 1).

Availability and access to technology. Though schools are becoming better equipped with the software and hardware, teachers still are not actively using computer-involving activities in their practice. Franklin (2007) in a quantitative study examined how elementary

teachers used technologies for instructional purposes and the factors that influenced their use of computers. He noted that computers are being used at schools in the following four ways: locating and gathering materials or teacher preparation for the lesson or unit; communication, i.e., e-mailing other teachers and parents; posting information, which includes posting assignments for students to do at home, grades for parents to see their child's achievements at school, or student's school attendance for the administrative staff; and writing lessons, or teachers creating instructional materials (Franklin, 2007).

Teachers are not confident in using technologies in their teaching, which reduces the time of computer use by students as well. According toBarron, Kemker, Harmes, & Kalaydjian's (2003) large-scale research study of technology integration into the schools' curricula as it is outlined in the NETS (National Educational Technology Standards), five levels of teacher's technology integration can be distinguished. They range from *highly integrated*, which happens when basic to moderate tasks are assigned on a weekly to daily basis; "more complex activities such as demonstration, e-mail, computer programming, and web page creation are assigned to anywhere from once or twice a semester to daily"; *integrated*, when technologies are used for analyzing data and creating presentations once or twice a month; *modestly integrated*, when basic tasks are assigned once or twice a month; *limited integration* with low-level tasks, such as word processing once or twice a semester and no complex tasks; to *no integration,* when technology is never assigned to students (Barron, Kemker, Harmes, & Kalaydjian, 2003, pp. 406-497).

The technology-use survey in "Infusing Technology Skills into a Teacher Education Program: Change in Students' Knowledge about and Use of Technology" gives a list of areas students and teachers should be proficient in to succeed in the process of technology

integration into the school curriculum. These include basic computer use, file management, word processing, spreadsheet use, database use, graphics use, Internet use, telecommunications use (e-mail), the understanding of ethical use of the technology tools, information searching, video production, and imaging devices (Collier, Weinburg, & Rivera, 2004).

Berg, Benz, Lasley II, & Raisch (1998) indicated that students can use a whole variety of technology for different purposes, which will increase the time of their productive computer-use for educational purposes significantly. These include multimedia authoring programs; scanners or digitizing cameras; computer/TV monitor for whole group presentations; CD-ROMs for research; computerized card catalog; Internet to communicate with other schools; Internet to e-mail students in other parts of world; Internet to do research; Internet to conduct research with other schools; World Wide Web (WWW); desktop-publishing software; computers in the writing process; computers to write across the curriculum; drill and practice programs; keyboarding software; problem-solving software; real-world problem solving; database programs; spreadsheet programs; to create art or music, and to work collaboratively.

Franklin (2007) offered three areas in which computers can be used by students: general software applications that include the software programs such as graphics for drawing and painting and a program that includes word processing, spreadsheets, and presentation/slide show; complex/multimedia and communication tasks which include Kid Pix for graphics and word processing, Graph Club for spreadsheets, or reader Writer for authoring; and practice/simulations which are e-mail, data analysis, and Hyper Studio for multimedia authoring. The author also gave as an example "a lesson on persuasive writing in

which the students select an invention and develop a commercial to sell the product" where students work with Power Point (Franklin, 2007, p. 269).

Though the number of computers in schools is increasing, still the computer integration into the school curriculum is developing. The quality of the computer use in schools (depending on the school), as well as the time devoted to the work on the computers worries educators significantly. According to Staples, Pugach, & Himes (2005), teachers pay more attention to training basic skills, and do not give much effort to the development of the higher-order thinking skills.

Public/private roles for technology recognition. The process of technology integration into the school curriculum cannot be completed without being accepted by students, teachers, school staff, and parents. Staples, Pugach, & Himes (2005) saw public/private recognition in student and teacher's willingness to obtain technology at a higher level and use it as a tool in teaching and learning. Pittman (2003) in his research about teacher preparation to use technologies in elementary classrooms spoke about the power of technology in building learning communities where students work independently; collaborate with peers and teachers from the class and from other schools, making projects using software as tools. Sweeney (2004), discussing the role of high-technology tools in student's work, added, teachers must realize that "different tasks need different tools or technologies" (p. 65).

November (1998) speaking about the features of the schools of future and George (2004) in the research of the features of the technology-rich community both mentioned parents being informed about their children's success via e-mail, or by having an opportunity to visit a school's website and follow the child's progress at school. Parents must realize that

technology expands the school borders and helps students to practice skills, or work on their projects at home as well as in school. Pittman (2003) insisted that learning can take place not only in schools or homes, but also in libraries, museums, parks, and even shopping malls. Technology-use outside school makes it happen.

Technology-integration cannot be just a policymakers' idea; it requires school and community support. From the research on the 21st century skills Maurizio (2004) concluded, public/private acknowledgement includes engagement of "educators, employers, community members, parents, and policymakers in an ongoing dialogue that provides recommendations and advice about 21st century education" (p. 30).

Challenges of Computer Integration in Classroom Work

The biggest difference between the Digital Natives and Digital Immigrants is their attitude towards technology. Millennials "have been exposed to computers since birth and have mastered the digital world in ways that their elders still struggle to comprehend" (Brogan, 2000, p. 57). Digital Natives are highly motivated by every technological innovation; their willingness to learn increases with computer work in the classroom. However, there are teachers who are not so fascinated by technology integration into curriculum simply because they do not know how to use it. Christensen (2002), in a study of the influence of technology-integrated curriculum on the teacher and student's attitudes towards technology, reflected, "It is critical that teachers possess both positive attitudes and adequate computer literacy skills to successfully incorporate technology into the classroom" (p. 412). A closer look at the existing barriers that make successful computer-integration in present day schools challenging will be taken in the following section.

Barriers to Successful Computer Integration

On the one hand, there are teachers who understand the importance and usefulness of computers in the classroom, and who indicate that computer has "considerable potential for allowing students to discover or construct ideas for themselves" (Franklin, 2007, p. 267). On the other hand, many teachers feel uncomfortable using such productivity software as word processors, database programs, drawing programs, and spreadsheet programs (Berg, Benz, Lasley II, & Raisch, 1998). Various authors speak about so called *barriers* to successful computer integration into the school curriculum. (Staples, Pugach, & Himes, 2005; Franklin, 2007; Hruskocy, Cennamo, Ertmer, & Johnson, 2000; Guha, 2003). These include the teacher preparedness to work with the software and use technologies in the classroom work.

Hruskocy, Cennamo, Ertmer, & Johnson (2000) saw one of the *key obstacles* to the use of computers in schools in the "limited support teachers have for integrating unfamiliar technologies into instruction" (p. 70). Franklin (2007) identified the three *greatest barriers* to computer use: the intense work necessary to cover the curriculum, lack of time in daily schedule, and high stakes testing. Guha (2003) added lack of financial support for computers to the above barriers. Hruskocy, Cennamo, Ertmer, & Johnson (2000) emphasized "lack of time to practice and explore available technologies, need for ongoing assistance, required changes in attitudes and pedagogical beliefs, need for a shift in traditional teacher's role, fear and confidence levels, and lack of relevancy of training to instructional setting" as the greatest barriers (p. 73).

> The U.S. Office of Technology assessment (1995) found that schools devoted no more than 15% of their technology budgets to professional development. More recently, Carvin (2000) suggested that professional development should be closer to 30%, but unfortunately was as low as 3% in some districts. Without time and monetary resources devoted to increasing staff expertise in technology use, effective integration was a struggle. (Staples, Pugach, & Himes, 2005, p. 286)

According to Hruskocy, Cennamo, Ertmer, & Johnson (2000), time is the greatest concern in the computer integration process even if teachers already possess the technology skills.

Ertmer, Addison, Lane, Ross, & Woods (1999) in the research on the teachers' beliefs about the role of technology in the elementary classroom talked about external and internal barriers. External, first-order barriers include "lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support" (Ertmer, Addison, Lane, Ross, & Woods, 1999, p. 1). Internal, second-order barriers cover "beliefs about teaching, beliefs about computers, established classroom practices, and unwillingness to change" (Ertmer, Addison, Lane, Ross, & Woods, 1999, p. 1). In addition the identified barriers are the support factors, such as leadership, access and availability, incentives, personnel support, external constraints (society pressure), and philosophy and preparation (Franklin, 2007). Hruskocy, Cennamo, Ertmer, & Johnson (2000) in their research tried to lessen the most common barriers to technology integration into the school curriculum that had been mentioned in the literature. They ranked all the barriers and made connections between them, which shows that after elementary school teachers overcome the first barrier they can move on to overcoming the second, and then the third and other barriers:

> Providing elementary students with expertise in using technologies provides teachers with ongoing assistance as they begin to use technologies in their classrooms, effectively addressing the second barrier. Changes in the attitudes and pedagogical beliefs of individual teachers are likely to occur within a larger supportive community. With students possessing expertise in technology use, the traditional teacher's role can shift from information provider to project manager when incorporating projects requiring the use of technology. (pp. 73-74)

The Need for Technology Staff Development Classes

As it was said before, "relatively few teachers feel well prepared to integrate educational technology into classroom instruction" (Franklin, 2007, p. 268). Smith (1998) affirmed, "It is not surprising that teachers have had difficulty integrating technology into their classrooms. They feel neglected, confused, overloaded, overwhelmed and under prepared" (p. 3). Sweeney (2004) emphasized, "Technology isn't about how much hardware or software your school has, but rather what tools your teachers and students need to succeed. Expanding your staff's view of technology is an important step toward realizing a comprehensive technology vision" (p. 65).

In terms of growing numbers of Millennials and expanding technology, "policymakers agree a key objective of instructional technology research efforts must be to help ensure the 2.2 million new teachers needed in the next decade have the skills to select and use instructional technology effectively" (Collier, Weinburg, & Rivera, 2004, p. 448). Christensen (2002) from the study of the influence of technology integrated curriculum on the teacher and student's attitudes towards technology noticed that higher student achievement depends on the quality of teachers.

It's a hard job to keep every teacher and student at the same high level of technology skills and knowledge because the technology develops so rapidly, and schools would have to continuously purchase new products and pay for the staff professional development. "Teachers and principals must always juggle multiple levels of professional development and expertise, moving back and forth between the technology itself and the curriculum" (Staples, Pugach, & Himes, 2005, p. 306). On the other hand, as teachers learn how to use computers

in their instruction, students enjoy the learning process more now and later understand the importance of computers in their learning (Christensen, 2002).

Staying Ahead of Computer Literate Students

Prensky (2005) in the research on how to satisfy the Net Generation student's learning needs classified 3 types of students: those who learn for knowledge, who study for grades, and those who "tune teachers out" claiming that the present-day school is irrelevant to their lives (p. 60). The motto of these students is "Engage me or enrage me" (Prensky, 2005, p.60). Teachers usually have problems with this third type of students because they fail to find engaging activities for such students. Both Prensky (2005) and Giles (2006-2007) in her reflection on how to connect computers and children speak about children being very skillful in using the new century developments. "Exposure to cell phones, DVD players, video games, computers, digital cameras, and iPods has made today's young people more technologically advanced than those of any previous generation" (Giles, 2006-2007, p. 108). The problem is that children acquire new technologies faster than adults, and students are more proficient in technology than teachers (Pan, & Carroll, 2002). Prensky (2001a) in his discussion of characteristics and needs of the Millennials suggested inventing methodologies for all subjects with the help and guidance of the Digital Native students.

Hruskocy, Cennamo, Ertmer, & Johnson (2000) in the project of community learners creation with the implementation of computer technologies into the elementary school curriculum noticed that when teachers were assisted by students, they felt more confident in integrating technologies into school subjects. Moreover, student/teacher learning teams were created, where teachers and students treated each other with respect, participated in the collective life of their school, were responsible for it, and tried to meet collective and

individual needs (Hruskocy, Cennamo, Ertmer, & Johnson, 2000). They suggested enhancing children's self-esteem by allowing them to be a mentor to a teacher. Workshops gave students an opportunity to share knowledge about computer software with administrators, teachers, and other students.

Brogan (2000) in the overview of the ways Digital Natives are taught gave advice to teachers on how to use students' knowledge about technologies in educational purposes:

1. Encourage computer-literate children to help in teaching other children.
2. Encourage computer-literate children to share their knowledge with teachers and make the two-way educational relationship happen.
3. Use educational software and training programs to help teachers acquire computer skills, and pass these skills along to their students.
4. Continue making efforts to improve technology training for teachers and to provide skills guidelines for elementary school students and their teachers.

Future of Technology in Schools

> Imagine gliding into the year 2020 and finding that schools have been replaced by virtual learning labs, with teachers facilitating instruction through distance learning, and students from America, the Philippines, and India learning side by side with students from Afghanistan, Brazil, France, and Kenya. Imagine that these students are not merely connected through digital cameras, but that individual holograms allow them to be physically present in three-dimensional form with complete access to their five senses and able to not only see and hear but also to touch, taste, and feel stimuli from a distance. (Kurzweil, 1999, cited in Mason, 2005, p. 46)

The words that sound like science fiction today are very likely to describe reality in the near future. Smith (1998) wrote about the world of interactive multimedia, where students are able to learn at their own pace, and teachers devote more time addressing students' needs and helping them in their work, rather than correcting numerous papers and filling out forms.

Subjects are predicted to learn at a higher level, though it seems inappropriate in terms of the student brain development. "The kids will master systems ten times more complex than algebra, understand systems ten times more complex than the simple economics we require of them, and read far above their grade level – when the goals are worth it to them" (Prensky, 2005, p. 64). Prensky (2001a) highlighted that the future math for children will include approximation, statistics, and binary thinking.

According to Pittman's (2003) research on technology integration into the school curriculum, the school of the near future, (because computer technology develops rapidly), will have the following features:

1. Classrooms will become borderless; there will be electronic learning communities that will bring together many people with different interests, cultures and age groups.
2. Fewer courses will be taught and the emphasis will be on productivity and technical expertise.
3. Diversity will grow but groups will preserve their identities, cultural differences and lifestyles by engaging more in faceless interactions.
4. Computers in classrooms, homes, and small hand-held devices will become common tools in the world of education.

All of this sounds like a dream, but a dream that can come true in several years. Life, people's perception of life, schools' appearances, and teaching methods according to the living conditions, socioeconomic situation in the country, and incoming students, change.

Conclusions and Recommendations

The goal of the paper was to find out how well present day public schools are prepared to approach the needs of the new generation of students – the Digital Natives – by using the technologies in the teaching/learning process.

The paper emphasized several ideas:

1. New students born after 1985 grow up surrounded by technologies and feel proficient in using them in their every day life.
2. Schools are on the way to be equipped with the last technological innovations.
3. There are certain benefits of using technologies to teach Millennials: such approach is informative and expands student's horizons; technologies allow students to make explorations of new learning concepts in a fun and exciting way; technology-integrated lessons help students to express their creativity, give them choices, and teach children to be responsible for their own learning; technology integration builds confidence both in students and teachers, gives teachers instructional ideas, and helps them to move from traditional lecture-style teaching methods.
4. There are also challenges to using technology in educational process, such as teacher preparedness to work with the software and use technologies in the classroom work; lack of time for technology integration and intense work to cover the curriculum; fear and confidence levels; attitudes and pedagogical beliefs about the technology-use in the classroom, personnel support; and society pressure.
5. Schools face the necessity to plan technology-integration into the curriculum in future with the more advanced technologies and more demanding in terms of technology-use students.

Several recommendations can be given to make the teaching/learning process in the present day schools more efficient:

1. Schools should be provided with the decent amount of computer software and hardware. There should be enough of computers not only in classrooms for group and individual work, but in computer labs as well.
2. Parents together with the schoolteachers should encourage students to use computers outside the classroom. If there are no computers at home, students should be able to use the ones in the schools' computer labs.
3. Teachers should be able to attend technology staff development courses where they can gain knowledge about technological innovations and practice technology skills. These courses will also make teachers confident in using technologies in the classrooms.
4. Teachers should gradually replace school technology specialists. In this case schools will save money and use them for other purposes, such as buying latest versions of software and hardware, and be at the same level of technological innovations as the rest of the country.
5. Teachers should actively integrate technology into their lessons, which will motivate students to learn and develop higher-order thinking skills, work collaboratively in the groups of students of the same or different schools, and gain social skills.
6. Teachers and students should work collaboratively in teaching each other and learning from each other's experience. They should create a learning community with respectful relationship and responsibility for the work they are doing with the group or individually. Students should be involved in learning and be active in that process.

This paper makes it clear that there is a lot of work to do to improve the quality of teaching and learning in the technology-integrated classroom and to find the right approach to the present day Digital Native students. The policymakers, school staff, parents, and students should work together to make the fantasies of the school of future come true.

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Appendix A

National Educational Technology Standards for Students

(From the International Society for Technology in Education, 2007: http://www.iste.org/inhouse/nets/cnets/students/pdf/NETS_for_Students_2007.pdf).

1. Creativity and Innovation.

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:

1.1. Apply existing knowledge to generate new ideas, products or processes.

1.2. Create original works as a means of personal or group expression.

1.3. Use models and simulations to explore complex systems and issues.

1.4. Identify trends and forecast possibilities.

2. Communication and Collaboration.

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning, and contribute to the learning of others. Students:

2.1. Interact, collaborate, and publish with peers, experts or other employing a variety of digital environments and media.

2.2. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.

2.3. Develop cultural understanding and global awareness by engaging with learners from other cultures.

2.4. Contribute to project teams to produce original works or solve problems.

3. Research and Information Fluency.

Students apply digital tools to gather, evaluate and use information. Students:

Plan strategies to guide inquiry.

Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.

Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.

Process data and report results.

4. Critical Thinking, Problem-Solving and Decision –Making.

Students use critical thinking skills to plan and conduct research, manage projects, solve problems and make informed decisions using appropriate digital tools and resources. Students:

Identify and define authentic problems and significant questions for investigation.

Plan and manage activities to develop a solution or complete a project.

Collect and analyze data to identify solutions and/or make informed decisions.

Use multiple processes and diverse perspectives to explore alternative solutions.

5. Digital Citizenship.

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students:

Advocate and practice safe, legal, and responsible use of information and technology.

Exhibit a positive attitude towards using technology that supports collaboration, learning, and productivity.

Demonstrate personal responsibility for lifelong learning.

Exhibit leadership for digital citizenship.

6. Technology Operations and Concepts.

Students demonstrate a sound understanding of technology concepts, systems and operations. Students:

Understand and use technology systems.

Select and use applications effectively and productively.

Troubleshoot systems and applications.

Transfer current knowledge top learning of new technologies.

Appendix B

NETS Performance Indicators for Foundation Technology Standards for Students: Grades Pre K – 2, and 3 –5.

(From ISTE, 1998: http://cnets.iste.org, cited in Roblyer, 2000, p. 144-145).

Prior to completion of Grade 2 students will:

1. Use input devices (e.g., mouse, keyboard, remote control) and output devices (e.g., monitor, printer) to successfully operate computers, VCRs, audiotapes, and other technologies.
2. Use a variety of media and technology resources for directed and independent learning activities.
3. Communicate about technology using developmentally appropriate and accurate terminology.
4. Use developmentally appropriate multimedia resources (e.g., interactive books, educational software, elementary multimedia encyclopedias) to support learning.
5. Work cooperatively and collaboratively with peers, family members, and others when using technology in the classroom.
6. Demonstrate positive social and ethical behaviors when using technology.
7. Practice responsible use of technology systems and software.
8. Create developmentally appropriate multimedia products with support from teachers, family members, or student partners.
9. Use technology resources (e.g., puzzles, logical thinking programs, writing tools, digital cameras, drawing tools) for problem solving, communication and illustration of thoughts, ideas and stories.

10. Gather information and communicate with others using telecommunications, with support from teachers, family members, or student partners.

Prior to completion of Grade 5 students will:

1. Use keyboards and other common input and output devices (including adaptive devices when necessary) efficiently and effectively.
2. Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.
3. Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use.
4. Use general-purpose productivity tools and peripherals to support personal productivity, remedial skill deficits, and facilitate learning throughout the curriculum.
5. Use technology tools (e.g. multimedia authoring, presentation, Web tools, digital cameras, scanners) for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.
6. Use telecommunications and online resources (e.g., e-mail, online discussions, Web environments) to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.
7. Use technology resources (e.g., calculators, data collection probes, videos, educational software) for problem-solving, self-directed learning, and extended learning activities.

8. Determine when technology is useful and select the appropriate tool(s) and technology resources to address a variety of tasks and problems.
9. Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources.

Appendix C

By-Grade Technology-Integrated Lesson Ideas

(From Roblyer, 2000, p. 138-139).

Pre:K drawing to support language development (Wachob, 1993).

Students can practice learning their addresses by using a graphics package to draw their own houses. The teacher writes the child's name and address on th ehouse. A bulletin board can be created to show everyone's house as part of the community, with connecting roads and surrounding landmarks.

Kindergarten: Video-assisted interviews (based on Wachob, 1993).

Each child gets to be the interviewer and ask another child questions while looking through the camera set on a low tripod. The interviewer starts with simple questions, and then gradually branches out. It is a good opportunity for language use and for focusing on someone other than themselves.

Grade 1: A project with teeth (based on Boehm, 1997).

Teachers use e-mail to connect their K-3 students with "key pals" around the world in order to exchange information on how many teeth the children loose during the year. This activity is used as a springboard for learning geography (locations of key pals), literature and culture (tooth-fairy traditions and other stories from their region), art (creating pictures or murals illustrating tooth fairy traditions), creative writing (e-mail messages to participants, poems and rhymes on teeth), and mathematics (graphing data on lost teeth).

Grade 2: A database Yearbook (based on Hollis, 1990).

This project is introduced as a "getting-to-know-each-other" activity at the beginning of the year with a curricular theme such as "Beginnings" or "Friendships". Students

brainstorm the 10 most important things they would like to know about each other. The teacher creates a database template and students work in pairs to enter it into the database. When the database is complete, students look for interesting relationships and ask and answer questions such as "How many students are still seven years old?" and "What is the most favorite color in the class?" They use a graphing program to produce graphs of class data. They create a yearbook for an individual class or across all the classes in a given grade by printing out each student's record, adding a picture to it, and producing a booklet with a graphic cover.

Grade 3: Estimating with Eye Droppers and Spreadsheets (based on Harris, 1994). The teacher begins this activity with a discussion of what is meant by predicting and estimating, and explains that the students will be using these processes to predict the number of drops pf water that can fit on a coin. After making their predictions, students begin the experiment, keeping accurate count of the drops. Then they record them on a form. They do this twice, noting any factors that would allow them to get more drops of water on the coin. The students repeat the same process with the tail side of a penny, then enter the data into a spreadsheet and complete Totals and Averages. When all students have entered their water drop records, the teacher discusses the results of their prediction and the actual drops. Discussion focuses on factors that allow them to get more drops on the coin. The experiment can be repeated by varying these factors.

Grade 4: History Bites on the Morning News (based onHolifield, 1992). This activity is designed to keep student interest high while developing skills in research, social studies, and communication. Students use an electronic encyclopedia to research a

topic in state history; then they plan and develop "video history bites" designed to be shown on the school's closed circuit television "morning news program".

Grade 5: Watching the Weather (based on Robitschek, 1993).

Teachers identify schools who wish to participate in a "weather data exchange", which may be done via e-mail or on a location on the school's website set up for the project. Each school or classroom involved must record the minimum and maximum temperature and rainfall for the past 24 hours. They should take these readings at about the same time every day and e-mail their data to the school partners. Each partner school or classroom has an opportunity to collect all the data called in, summarize it in a chart, and present it to the other classes. Students can compile and plot the data over time, comparing information on and talking about the different areas involved, or talking directly to the schools about their weather conditions.

Grade 6: Visualizing Colonial America (based ob Sherwood, 1994).

Students can make history come alive by using a using the Colonial America 1760's videodisc in conjunction with role-playing. They create buttons to allow other students to look at various occupations of colonists. After viewing and discussing the segments, the students act out the roles of colonists, the Royal governor, colonial assembly member, and British magistrate.