The impact of information communication technology on student achievement

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Abstract

Information and Communication Technology (ICT) tools are common resources used within learning environments worldwide. These tools can range in complexity from the most basic such as calculators, word processors, and presentation software to more complex tools such as simulators or video editing packages that in turn require greater end-user skills. The Internet also serves as a teaching and learning resource by providing real-time information and communication abilities. This report focuses on the impact of ICT tools within learning environments and has discovered that information and tools inadvertently do not guarantee greater attainment. Research suggests that students must be equipped with skills to use information and tools to create new meaning and knowledge and teachers, in turn, must scaffold this learning process. If used to enrich student learning by facilitating higher-order thinking and reasoning, ICT tools can affect student achievement positively. If however, such tools are not enriching the current learning environment, student learning can be hindered. This paper examines how ICT tools are being used within learning environments internationally; the effect of ICT on student achievement; and successful ICT rich learning environments vis a vis the project-based learning model of teaching and learning.

Keywords: information communication technology, project-based learning

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Background

Internationally, a great deal of resources have been put towards purchasing computers, hardware, software, and networking systems in the attempt of educating and providing students with the technological skills that are needed in the 21st century (such tools fall under the realm of information communication technology and throughout this research will be referred to as ICT). Each nation is in competition to educate and train their citizens to become the leaders and inventors of tomorrow. The information economy requires a “skilled work force to cope with constant changes in the workplace as well as in day-to-day living. Adults require higher skill levels as society becomes more complex, low-skill jobs decrease and literacy requirements increase dramatically” (Corbett & Willms, 2002, p. 8).

In Canada, the federal government has created policies and programs so that all schools and communities have access to ICT. One such example is the SchoolNet program, whereby the main focus is to provide all schools and classrooms with Internet connections. Within communities, high-speed Internet connections were established by way of the Community Access Program (CAP), which in turn was advantageous for rural Canadians who might have resided in areas where high-speed Internet connections were not available (Corbett & Willms, 2002).

In 2003, the Government of Nova Scotia with the assistance of the federal government invested approximately ninety million dollars towards the Information Economy Initiative (IEI); a technology rich plan aimed at connecting and preparing Nova Scotians for the Information Age. This endeavor, which was completed in 2007, resulted in computers for schools, training for teachers, and Internet access for rural institutions.

With the vast amount of time, money, and effort invested in ICT, it is important to investigate the effects of such tools. Therefore this research will focus on if the integration of ICT tools has a positive effect on student achievement?

Definitions

For the purpose of this paper it is important to define student achievement. In the basic form, educational achievement is determined by formal assessment measures such as tests, quizzes, and standardized examinations. Students are graded based on their recall abilities and given a mark based on the desired or correct answers. In other cases, student achievement is gauged based on summative assessment measures such as projects, portfolios, or learning logs. The goal of such measures are used to determine if in fact students have developed knowledge based on the current content studied. Therefore if students are able to meet or exceed learning outcomes, they have achieved.

Furthermore, achievement is a dependent variable, a product of a combination of factors. Hurd, Mangan, and Adnett (2005) describe the “educational production function approach” whereby “the school serves as a production unit that has an intake of students, and uses resources…to add value in terms of increased educational attainment” (p245). Such resources are time, money, structures, people, books, or technology. However it is also important to note that factors outside the schooling environment, such as community, family, and friends also play a role with the context of learning and achievement.

Schools serve the purpose of preparing the adults of tomorrow and equipping them with the skills and aptitudes needed in society. This idea is developed furthermore by Fernandez (2008), “The role of schooling is to do more than simply prepare people to make a living.

Schools prepare people to live full lives and to participate in their communities, to raise families, and to enjoy the leisure that is the fruit of their labor" (p 15). Because of the vastness of curricula within the context of schooling, it is sometimes difficult to develop outcomes for all real life proficiencies learned. However, it is important to take into account these skills when assessing learning. When developing curricula, it is important to consider the skills that are needed and demanded by society within the present information economy. Such considerations can be found worldwide with billions of dollars worth of resources dedicated ICT and learning outcomes that focus on important technological competencies at key stages of learning.

ICT and Achievement

Reynolds, Treharne, & Tripp (2003) pose valid questions regarding the correlation between ICT and achievement, "Do high performing schools, as a facet of their performance, invest in both the human and physical capital at the cutting edge of school improvement, including ICT, or does investment in the human and physical capital of ICT result in school improvement?" (p.152). This being said, when examining the integration of ICT in schools, any learning prior to technology integration must serve as a starting point so that any advances in achievement are clear and can be attributed to the enhancement of resources.

Hurds et al. (2005) reinstate claims made by Fuller and Clark (1994) that an increase in educational resources such as books and instructional materials has a greater effect on school performance than an increase in teachers or a reduction of class sizes. It is based on this premise that governments have purchased a great deal of technological resources for schools with the intent of increasing the use of ICT within the classroom (Hurds et al., 2005). Those opposing these huge investments contend that money should be put towards traditional resources such as books, teachers and bricks and mortar and call the idea that ICT positively influences learning and achievement and raises standards, “optimist rhetoric”(Reynolds et al.,2003, p.151). The claims of the benefits of ICT on student achievement Reynolds et al.(2003) explain, is an attempt by “politicians, industrialists, policy makers, civil servants, local government advisory services, the media, related ICT support bodies and national agencies” to justify the great deal of resources and time put towards ICT since the 1970s (p.151).

This being said, money continues to be spent on technology resources for the classroom. If the trend continues it is safe to presume that a great deal of learning resources used daily will be technology based. Therefore it is important to note that access to ICT is not equal for all students. For example, students that live in more rural areas as well as students of Aboriginal decent report lower usage rates (Looker and Thiessen, 2003). Teachers must be aware of such factors when assigning work to be completed at home or for enrichment; not all students will have the same learning opportunities.

This being said however, money continues to be put towards technology in schools based on broad statements by intellectuals such as Guile in Reynolds (2003), “ICT can lead to tremendous gains in student learning, for example, significant improvements in examination or statutory test performance, development of broader forms of social, cultural and intellectual capability”(p 153). He furthers his claims by noting that with such changes in educational resources, teaching styles must also change whereby teachers must create “new contexts as well as new learning processes to support learning with ICT” (Reynolds et al., 2003, p. 153). Learning environments that are rich in ICT exhibit integrated lessons that are differentiated, inquiry-based and learner-centered allowing students to develop knowledge based on experiences or hands-on initiatives. This is a stark contrast to traditional learning environments whereby the teacher serves as an information bank, the beholder of knowledge, and students learn in a linear manner.

Evidence

Success within learning is not only measured by number or letter grades, but is also measured by increases in critical thinking, motivation, self-esteem, problem-solving or creativity. By providing students with differentiated learning experiences that incorporate ICT tools and varied assessment measures, educators can delve into skill sets not exhibited in traditional learning environments. UMESCO Asia and Pacific Regional Bureau for Education (2004) in the case study of six Asian countries, found that the use of ICT tools "helped to improve greater autonomy in learning, stimulate students' sensory and cognitive curiosity, develop life skills, boost self-confidence and facilitate the learning of abstract ideas and theories" (p129). Furthermore, the use of technology within learning environments can increase communication skills by enabling students to collaborate and cooperate with peers and teachers. This ongoing communication and dialogue can result in higher-order thinking skills beyond grade level expectations for the reason that students are constantly questioning, debating, and bring new meaning and understanding to content by way of conversations.

Students of the 21 century regard technology tools as appealing and as a result, the tools are seen as motivating factors that draw and maintain student attentiveness. Reynolds et al. (2003) found that students were interested in the work that made use of ICT tools and that they were more motivated to complete their work and consequently stayed to complete school work during leisure time.

Reynolds et al (2003) in their survey of teachers on the use of ICT in British secondary schools reported that ICT tools enabled students to "express themselves more clearly" within the subject of literacy (p. 161). Tools such as word processors, presentation software, and text to speech software were also used to scaffold student writing, reading, and spelling and literacy skills. Teachers, in turn, claimed that students were "more resourceful…creative… (and had an) enhanced sense of achievement in learning" when working on projects that incorporate ICT tools (Reynolds et al., 2003, p. 161). Within the subject of math, students used ICT tools to perform calculations and computations that might have been time consuming if done by manually. These tasks require low level reasoning and by using ICT tools, more time could be used to perform higher order thinking and reasoning. Also, tools were used to facilitate student learning in science by allowing students to make abstract ideas concrete by using animations, videos, and simulations, "This should make Science seem more real and proximate to pupils, rather than being a distant and separate area. It can also facilitate links being made between the science which is taught in schools, and the experiences of pupils in their everyday lives, thereby enriching their scientific understanding experiences" (Reynolds et al., 2003, p. 158).

The British report ImpaCT2, which has been deemed one of the most thorough investigations into the relationship between ICT and educational achievement, was developed to review advances in academic performance of British students at three stages 11, 14, and 16 years old over the two year span of 1999-2001. In doing so, it evaluated the effects of the National Grid for Learning program, an ICT based initiative, on student achievement. At all three key stages, student test scores in reading and Mathematics were averaged and compared to results taken prior to commencement of the study (Harrison, Lunzer, Tymms, Fitz-Gibbon, and Restorick, 2004). The results of this study illustrates "statistically significant findings "that ICT does play a role in student achievement; however the benefits are not “spread evenly across all subjects” with higher levels of achievement were evident in Science, Math, English, Modern Foreign Languages and Design Technology (Harrison et al., 2004, p.336).

From this investigation the subject Science showed the greatest impact with increases in achievement. On the other hand, the subject of English showed less direct impact on achievement than other subjects although students were highly engaged while learning English with ICT tools. One such reason could be that topics in English such as writing and reading require practice and without it students may not be able to apply the concepts to varying situations successfully such as on standardized tests. For example, if within a lesson short stories were listened to and questions posed to students they may be able to answer orally, however may not be able to record their thoughts properly with few spelling and grammatical errors. Therefore, students may enjoy a different style of learning, however in all cases it does not result in increased achievement.

Aforementioned, Science encompasses many abstract ideas and theories and because of the intangible nature of the subject matter, many students may find the content difficult to grasp. With the capabilities of some ICT tools, these topics can be explored to a greater degree and as a result once abstract ideas can become concrete. For example, understanding the components of cells in Biology can seem daunting for some students. However, by using high tech microscopes and computer simulations, students are able to visualize and make sense of the mechanics. In this case, ICT tools create a live experience for students not attainable by books alone. Therefore if tested on the mechanics of a cell on a standardized test students are able to relive the experience of the live cell.

Other data supporting the idea that the integration of ICT positively effects student achievement can be found in the West Virginia Basic Skills Longitudinal Study (WVBSL), Apple's Challenge 2000, Karagiogi and Charalambous's 2006 study on a rural public school in Nebraska, and Florida's Project CHILD. Project CHILD (Changing How Instruction for Learning is Delivered), an educational program that consists of approximately ten thousand students in total, "employs a triangulated design with three teachers working as a team across three grade levels with three years to work with students. CHILD also moves beyond textbook teaching to incorporate technology and hands-on active learning at differentiated learning stations" (IFSI, 2007, p. 2). In a report that compared standardized assessment measures among twenty-four hundred active CHILD students with those seventy-six hundred students not within the specialized program, found that those enrolled in the CHILD program outperform their peers 82% of the time in reading, and 70% in mathematics (IFSI, 2007).

Furthermore, in his analysis of the United States' National Assessment of Education Progress (NAEP) database, Wenglinsky (1998) found that among eighth graders, "using computers for higher order thinking skills were each associated with more than one-third of a grade level increase"(P 6). His assertion, therefore, is that technology can affect student achievement depending upon "how it is used" (Wenglinsky, 1998, p.34) Therefore, when technology tools are used to perform high-level tasks and when teachers are proficient enough to scaffold this process, "computers do seem to be associated with significant gains in mathematics achievement" (Wenglinsky, 1998, p 34).

It is apparent that increases in achievement within math and reading levels were evident in students who used, and had access to, technology within their learning environments on an ongoing basis. Within these learning environments teachers taught with and students learned with and from technology which in turn is attributed to increased achievement (Reynolds et al. 2003, Harrison et al., 2004, Hurds et al. 2005, Karagiogi & Charalambous, 2006, Chandra et al. 2008).

At this point, it is important to acknowledge the fact that some argue that the integration of ICT in learning activities does not produce statistically sound supporting evidence. Research has been conducted yielding results that prove no significant difference in learning. McFarlane and Sakellariou (2000) assert that because the nature of learning is extremely complex with many contributing and uncontrollable factors, accrediting the integration of ICT tools the sole reason for improved attainment is naïve. Furthermore, their research reviewed over one hundred and two studies of the effects of ICT on achievement and found that the technology alone cannot be used as a measure. Rather, secondary effects such as “motivation, concentration, cognitive processing, reading comprehension and critical thinking” of ICT are better inclinations on improved student attainment (p10).

Can the integration of ICT hinder learning?

Another issue that does not follow the original premise is that technology integration could in fact hinder student performance. Students are attracted to technological tools, however “high levels of use may even be counterproductive” (Wenglinsky, 1998, p.34). If the sole purpose of incorporating such tools into daily lessons and activities does not support educational goals and outcomes then student time could be wasted. If students could learn and create new knowledge easier without such tools then the tools should not be used. Technology should serve the purpose of making work easier or enriching the lesson. Wenglinsky (1998) discovered that “the use of computers to teach lower-order thinking skills was negatively related to academic achievement and the social environment of the school” (p.5) It is at this point that teachers and parents should be cognizant of this and assure that the tools being used for educational purposes do not have a negative effect (Looker and Thiessesn, 2007). Furthermore, information in itself does not result in knowledge acquisition therefore students must be encouraged to develop and use skills that will further their understanding and learning. As a result of the complexities that arise with the integration of technology, it is important to review effective uses of ICT within learning environments.

Effective use of ICT within learning environments

Modern pedagogy is rooted in constructivism whereby students are encouraged to apply their own experiences and prior knowledge to current learning situations. Therefore educators must provide students with such opportunities. Within this ideology is the concept of authentic learning whereby learning is student-centered as opposed to instructivist, teacher-driven. Authentic learning activities are relevant to curricula and appeal to student interests while also having connections to the real world. Therefore students can work collaboratively questioning and reflecting on real-time data and information in the quest of developing new knowledge. A common authentic learning activity is project-based learning (PBL).

Project-based learning

At this point it is important to make note of the difference between problem-based learning and project-based learning. In problem-based learning, students solve real-world problems or questions by analyzing and interpreting data and information, collaborating with peers, and applying prior knowledge. Project-based learning on the other hand, differs due to the size, complexity and final ending point. Project-based learning is a larger process and typically consists of multiple problem-based learning endeavours. As opposed to ending with a simple solution, project-based learning ends with a student-made artefact.

Project-based learning consists of two main parts: (1) a general topic or theme is presented to learners who in turn create or identify a problem(s) that will serve as the focus of their research and (2) the solution to the problem(s) results in a complex artifact that is unique to the individual (Greene and Land. 2001). Blumenfeld (1991) outlines the activities of students within PBL environments, “students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts” (p371).

Students reflect on past experiences and knowledge while embarking on the quest of solving the problems at hand. This may result in a great deal of relevant cross-curricular connections as referred to in Yamzon (1999), “students learn to draw from, manage, and allocate resources from many disciplines in order to solve problems” (p7). PBL appeals to a great deal of learning styles because of the degree of choice and flexibility. Therefore students are active participants who are self-directed and interested in the process of learning.

Because problem-solving and collaboration are key components of PBL environments, students are continuously analyzing, predicting, hypothesizing, synthesizing and debating. Therefore students are participating in higher order thinking while engaging in investigation (Blumenfeld, 1991). In addition to potentially increasing student learning, PBL activities can also “motivate students to think critically, and challenge them to learn” (Faris, 2008, p.3)

PBL also encourages creativity through the development of artifacts. Students are able to create individualized projects that vary considerably, however meet the learning outcome nonetheless. This appeals to various learning styles and abilities and creates a sense of pride and mutual respect among students. Yamzon (1999) in a small ethnographic study on PBL discovered that the more engaged, motivated and invested students are in projects, the more they learn that in turn results in greater achievement.

PBL and ICT

ICT tools such as computers (either stand alone or networked) as well as the Internet are prominent scaffolding instruments in PBL. Students can use various technologies to: gather factual based evidence; organize information; analyze data; prepare presentations that consist of not only text but audio, animations, or video; and to collaborate with peers and experts to question, share findings, or to provide feedback (Faris, 2008). Although PBL can occur without the use of technologies, it has been discovered that students who use technology tools to support the processes during PBL outperform students who did not use technology within the realm of communication, teamwork and problem-solving strategies (Fernandez, 2008).

Wenglinsky (2006) found that the integration of technology for younger students (middle school and lower) increased achievement when used as a means of enriching the lesson, providing opportunities for students to attain higher-order thinking. On the other hand, technology in high school environments affected achievement positively when used as tool to "deepen their thinking and enhance their work products through technology driven processes". (p. 31)

Aforementioned, student interest and motivation in learning activities plays a role in achievement. As an educator of the Net Generation of students I, as well as many of my colleagues, have witnessed student appeal with Web 2.0 technologies such as cell phones, iPods, game consoles and social networking websites. Therefore it is safe to presume, that incorporating similar technologies could potentially maintain student interest. Blumenfeld (1991) noticed this fascination with technology and furthered the uses beyond basic communication, "technology can enhance interest by providing multiple levels of activities that match students' knowledge and skills and give them access to real, authentic data" (p 385). Furthermore, Ungerleider & Burns (2002) discovered that student interaction within group settings as well as the use of technology tools to facilitate learning resulted in increases of student satisfaction and motivation; and students who are motivated in turn, experience greater success.

PBL and Achievement

Wenglinsky (2006) when analyzing American high school history scores from the NAEP determined that among other uses for computer technologies within learning environments, using technology to complete relevant projects promotes student achievement. Therefore, because of the complexity, authenticity, and the use of technology, students are motivated and have invested interest in PBL which results in greater achievement. This is affirmed by Yamzon (1999),

> "In solving complex problems students learn more than the standard academic skills that are traditionally taught in the classroom. As students develop and apply those skills in a meaningful context, not only do they gain further mastery over those skills and a deeper understanding of their applications, but they also learn essential real life skills that are not typically taught

> in schools. When students are given the chance to learn through experience, students learn how to learn, as well as gain an appreciation for learning”. (p 31)

The effect of gender within technology rich learning environments should also be considered when reviewing achievement. Kuiper, Heemskerk, van Eck, and Volman (2005) discovered that female and male students generally took on different roles when working cooperatively on technology based projects. Females, for the most part, take on the reporting roles of the group organizing information and preparing presentations while paying close attention to detail and elements of design and color. Males, on the other hand, focus on the technical aspects of the project and exhibit more of a competitive edge. Because of the apparent nature of preferences, this factor is important to keep in mind when designing PBL environments. If the project is limited and does not allow for student role preferences some students might not be invested in the tasks and therefore not achieve to the best of their ability.

An example of PBL and ICT

Students are organized into groups of three and given the theme of the endeavor, “Trigonometry in the year 2009: How does it affect you?” From this topic, students would record any prior knowledge of trigonometry and look to immediate resources from their textbooks or classroom resources. Once some knowledge has been gathered, students then could further their research on the topic by using resources such as videos, animations, or the Internet. Some students could take a mathematical approach to answering the question, while others may look to their surroundings to find concrete examples of the concepts underlying trigonometry. The teacher in this case, would act as a coach posing questions, pointing out similarities, and connecting students’ findings with their prior knowledge while facilitating and nurturing the creation of new knowledge. At all aspects of the learning process technology is immersed so that students are enabled to perform higher order thinking. More important however, is, "teachers' coaching in making students aware of their ongoing monitoring and meta-cognitive processes in accomplishing the group project task" (ChanLin, 2008, p.64). At the end of the project, students will have produced some sort of artifact that solves the original question. This may be in the form of a PowerPoint presentation with mathematical reasoning, diagrams, and real-life visuals or it might come by way of a model or simulation.

Recommendations

Based on this research, information communication technology tools can have a positive effect on student achievement. Technology, however, is not a savior for poor teaching practices. Successful learning environments are rooted in constructivism and provide students with the ability to apply prior knowledge, skills, and aptitudes to present learning activities. Project-based learning focuses on student-directed, authentic tasks whereby students are engaged in meaningful, real-life activities. Technology can scaffold such activities and provide students with the ability to attain higher order thinking; hence increasing achievement. When incorporating technology into PBL, teachers must monitor proper usage so that all tasks are value-added and contribute to the overall learning process. Future consideration must focus on how to properly organize and develop technology rich activities so that greater achievement can be realized across all content areas. With students engaged in and demonstrating highly great aptitudes for Web 2.0 technologies, we must strive to determine how we could foster such skills within our classrooms and learning environments.

Conclusion

From this research it is apparent that ICT does affect achievement by way of increasing test scores, motivation or facilitating collaborative learning. ICT tools, and more generally technology, do not guarantee success however. Learning environments must be rooted in constructivism and teacher support and scaffolding is necessary throughout the entire process. Activities must be rich in content and advance thinking by requiring students to work through complex problems rather than perform low level processing tasks. Wenglinsky (2006) states that teachers must not use technology as mere “drilling machines” but should incorporate tools that can serve as “catalysts of creativity” (p. 30). In closing, the full potential of ICT tools is not being realized because teachers are not incorporating such tools efficiently. Further consideration should be put towards incorporating ICT tools into educational theory; perhaps giving way to a hybrid theory with roots in constructivism and a focus on technology.

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