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Using technology to encourage critical thinking

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Abstract

As technology continues to change educators must be willing to make adjustments in their teaching strategies and make an effort to make technology a permanent part of the curriculum. Critical thinking consists of organizing knowledge in a meaningful manner so it can easily be used by the learner. Those applying critical thinking are more motivated and perform at a higher level of performance than students using lower level thinking skills. Technology continues to become a bigger part of education and teachers need to use databases, spreadsheets, and concept maps as tools to facilitate critical thinking. Educators need to be aware of the barriers to technology integration such as the lack of training and lack of administrative support. This review will demonstrate how technology can be used as "mindtools" and how using technology in this manner will benefit students.

Using Technology to Encourage Critical Thinking

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Tracy Wilkins

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Abstract

As technology continues to change educators must be willing to make adjustments in their teaching strategies and make an effort to make technology a permanent part of the curriculum. Critical thinking consists of organizing knowledge in a meaningful manner so it can easily be used by the learner. Those applying critical thinking are more motivated and perform at a higher level of performance than students using lower level thinking skills. Technology continues to become a bigger part of education and teachers need to use databases, spreadsheets, and concept maps as tools to facilitate critical thinking. Educators need to be aware of the barriers to technology integration such as the lack of training and lack of administrative support. This review will demonstrate how technology can be used as "mindtools" and how using technology in this manner will benefit students.

Introduction

Technology is advancing everyday and it is impossible for education to keep up with the always changing technological world. As technology continues to change educators must be willing to change along with it and make an effort to make technology a permanent part of the curriculum. There are several questions that need to be answered involving technology being used in a way that encourages or enhances critical thinking:

1) What is critical thinking and does it benefit the learning process?

2) Can technology be used in a way that encourages critical thinking?

3) What examples are available to demonstrate technology being used to foster critical thinking?

4) What barriers exist for teachers integrating technology into the curriculum as a way to encourage the use of critical thinking skills?

This review will explore how technology can be used not only as a production tool but also as a tool to encourage students to use critical thinking skills. One of the goals of education for many years has been to create instruction where students use higher-order thinking skills. This paper will present the case that changing technology can create situations where students have a tool they can utilize to assist them with critical thinking. It is important educators start teaching students how to use technology as tools to assist them in learning and avoid teaching specific software packages, because it is impossible for education to keep up with the speed technology is changing. According to John Kalny (1999), educators should recognize the fact that when a school purchases new technology, it is rapidly growing out of date, so it is important to make an investment in the human part of education as well as the technology. This idea of

teaching students how to use the tools regardless of the software or format of the tool being used is important to facilitate their learning process.

First, this review will examine the term 'critical thinking' and will evaluate several literature resources to develop a common definition for this review. Education continues to put an emphasis on standardized test scores and this review will establish that it is critical thinking that is necessary for long-term learning. Literature will be cited that supports the belief that the stronger the students' critical thinking skills the higher the students' performance will be on certain tasks. Educators need to take this into consideration when developing lessons and curriculum. The use of technology will be very beneficial in enhancing students' critical thinking skills. The primary purpose of this review is to demonstrate how technology can be used to enhance critical thinking skills.

Another very important issue in technology integration is the ability of educators to use technology as "mindtools". Educators need to create instruction where students are challenged to use technology to enhance their learning experiences. Jonassen (2000) defined "mindtools" as being computer-based tools that function as intellectual partners with the learner in order to facilitate critical thinking. An additional goal of this review will be to examine how applications such as databases, spreadsheets, and concept maps can be used as "mindtools".

Along with professional development for teachers and instructions regarding technology integration, educators should be prepared for the various barriers that exist when using technology in the classroom. Some of the barriers include lack of administrative and financial support. Another barrier is the increased pressure put on

educators when assessing students' performance. These barriers can make integrating technology into the curriculum almost impossible to accomplish.

This review also addresses the idea of using the World Wide Web or the Internet as a tool to facilitate critical thinking. The majority of the literature sources reviewed addressed the issue of how to integrate the Internet into the curriculum while at the same time encouraging students to use critical thinking skills. Several authors have addressed how to use Internet databases and search engines to facilitate critical thinking. This section will also provide an example of a project on the African-American Civil Rights Movement and the results of the study completed on students participating in this project. This review will examine several items dealing with integrating technology into the curriculum and demonstrate how beneficial facilitating critical thinking is on student learning.

It is important that educators continue to become accomplished on the different uses of technology and how to use the available resources to support critical thinking. This review of literature will describe the use of databases, spreadsheets, concept maps, and the Internet to facilitate critical thinking. This review will also cover training teachers to use technology and the barriers that teachers need to overcome to integrate technology into the curriculum to encourage critical thinking.

Methodology

The methods for identifying resources for this review started with four questions:

1) What is critical thinking and does it benefit the learning process,

2) Can technology be used in a way that encourages critical thinking,

3) What examples are available to demonstrate technology being used to foster critical thinking,

4) What barriers exist for teachers integrating technology into the curriculum as a way to encourage the use of critical thinking skills?

The research consisted of searching professional journals in the area of technology education. Most of the professional research was limited to publications in professional journals as a result of searching ERIC. The research was also expanded to papers and studies presented at national conventions of various professional organizations such as AECT (Association for Educational Communications and Technology). The research for these documents was the result of ERIC searches for ED documents pertaining to technology integration and critical thinking. The University of Northern Iowa's Rod Library database of Educational Full Text documents was also searched with the same criteria. The research was later expanded to include an external source database called Wilson Web and the research on this database was limited to only articles published in professional journals.

The results of the research were limited to include articles found from the 1990's to the present, authors or studies dealing with integrating technology to enhance critical thinking, or articles dealing with defining critical thinking. The last piece of research was a book by David Jonassen (2000). This book is the backbone behind this research and overwhelmingly supports the use of technology as tools to facilitate critical thinking.

Analysis

Defining Critical Thinking

The first aspect of this study was to examine the definition of critical thinking and to establish a definition to be used throughout this review. It is important to understand that a universal definition for critical thinking does not exist, but for the purpose of this paper two definitions were studied and adopted. A panel of critical thinking experts defined critical thinking as a purposeful, self-regulated judgment which results in the interpretation, analysis, and evaluation as well as developing evidence or contextual situations upon which a judgment can be made (Gordon, 2000). Unfortunately, for the purpose this paper, that definition seemed to be too complex, so the following definition will be used: critical thinking consists of organizing knowledge in a meaningful manner so it can be easily used by the learner (Jonassen., 1995).

There are three main areas that need to be addressed when examining critical thinking skills; evaluation, analysis, and connecting. Jonassen (2000) splits these areas into general skills. Evaluation is the idea of taking information and sorting through it to make decisions on what information is relevant and what information can be eliminated. The evaluation process consists of a person being able to search and retrieve information from sources and make decisions on what parts of the information is reliable versus the information that needs to be discarded. The analysis process involves the information the learner has retrieved and sifting through it and initiating the organizing process. This process may require the separation of parts of information so the learner can make sense of it and then make connections to previous knowledge. This is the last step of critical thinking. This is the ability of the learner to take the information they have evaluated and

analyzed and then make connection to previous knowledge so the information that is considered to be useful can be retained (Jonassen, 2000).

Technology's Role in Critical Thinking

There have been several studies completed in the area of technology integration for the purpose of facilitating higher-order thinking skills. This review focuses on four areas of technology; databases, spreadsheets, concept maps, and the Internet. This review begins with a study of how databases, spreadsheets, and concept maps are used to support critical thinking.

Databases seem to be the most common area of technology utilized to facilitate critical thinking. The possible reason for this is because databases are designed to sort, organize and analyze pieces of data or information. Databases are computerized record keeping systems which were developed to eliminate the paper-based filing system. Database systems provide the capability of sorting, organizing, and managing information while creating and defining new database files (Jonassen, 1995). This application allows learners more control in their own learning process by using the database to make connections. In the area of mathematics, databases are used to provide the students with the ability to classify and sort mathematical information, which is a fundamental mathematical skill. Using databases in this manner supports Vygotsky's theory of concept development, forming relationships between and among physical objects on various levels and then the ability to abstract properties from a physical object. (Harvey & Charnitski, 1998). Databases assist in this transformation as they provide a tool for students to use to visually present information in a manner where students can form these relationships earlier in development (Harvey & Charnitski, 1998).

Student-prepared databases require students to determine the information that needs to be collected and then sort and organize that information. The students can then use the collected information to make connections and organize information in a meaningful manner (Jonassen, 1995). Lytle (1999) provided another example of using databases to encourage critical thinking in a way similar to that described by Jonassen (1995). In a study, business education students were required to create a database on where they had been employed or for those who have not been employed they identified a store that they frequently visit. Using a relationship database, students then examined a familiar business and made connections between what functions were necessary for the operation and success of the identified business. Once students had created the database they could visualize and make inferences based on their database. The purpose behind this project is to create a database where students could make connections between what they are familiar with and what functions are necessary for the success of a business (Lytle, 1999). These examples of using databases to make connections by organizing and evaluating information are what Jonassen (2000) calls "mindtools". This demonstrates how databases have been used in mathematics and business to promote the used of critical thinking skills and is consistent with Jonassen's (2000) definition of critical thinking.

Another application used by educators to promote higher-order thinking skills is spreadsheets. Typically, spreadsheets are used in the area of mathematics and business. A spreadsheet is a tool used for organizing and manipulating numerical data that students can use to manage and create relationships with numerical information (Harvey & Charnitski, 1998). Spreadsheets require students to make their own connections and

determine relationships based on the students' experiences and knowledge. Even though students can create relationships using spreadsheets, educators must proceed cautiously because it is very easy for students to only enter numbers into spreadsheet which will involve using lower-level thinking skills. It is important students use spreadsheets to identify, describe, and classify relationships to guarantee critical thinking is taking place (Jonassen, 2000).

The previous section provided examples of how databases and spreadsheets can be used to encourage the use of critical thinking skills. Using these applications as mindtools represents an effective and efficient way to engage learners in critical thinking (Jonassen, 2000). In the Wolf & Brush (2000) study of thirty-five 8th grade students, databases were used as research tools. The students were split by gender and half of the students were given guidance on how to use databases as scaffolds while the other students were not given the training. Both groups were required to write a research paper. Throughout this study there was a considerable difference in the quality of the students' research reports. The group that used databases as scaffolds had an easier time, which resulted in higher quality papers. At the conclusion of the study, it was determined there was a statistical difference when comparing 8th grade students using scaffolds to write research papers versus student not using them (Wolf & Brush, 2000).

Concept maps are also used as tools for students to evaluate and analyze information. Robertson (2000) studies two approaches for brainstorming. The first approach was having students brainstorm what they already knew about a lesson while the instructor wrote the results on the white board or poster board. This approach worked very well, but limited students' ability to make their own connections and forces them to

make the same connections as the class makes through the brainstorming activity. Another approach studied was using Inspiration software to develop electronic concept maps. This approach allowed students to make their own connections while defining their own relationships with their person knowledge and experiences. Students could then use the concept maps to explore the Internet and subsequently deepen their knowledge. This type of research gives students opportunities to think critically while completing their concept maps because they are able to make sort and organize information to make there own connections (Robertson, 2000).

The concept of using the World Wide Web to do research allows students to actively participate in gathering information and manipulating the information to make connections. This makes the Web a very effective device for performing a critical analysis of material (Vess, 1997). Using the Internet to facilitate critical thinking allows educators to give the reins of learning back to the student. According to Jonassen (2000), learning takes place when students think in a meaningful manner and thinking needs to be an engaged process. Based on this principle, learning needs to be an active and engaged process. The use of Internet databases for research gives students the freedom to be in control of their own learning process. Crane and Markowitz (as cited in Murry & Graham, 1996) believe on-line searching involves problem-solving skills which promotes higher-order thinking skills such as critical thinking. Murry & Graham (1996) go on to describe an activity where students created a list of keywords related to a research problem and defined the relationships of these words with regards to the problem. The concept of identifying keywords, analyzing them, and then making connections is exactly

what has been defined as how technology supports critical thinking throughout this review.

Internet research can give teachers the freedom to allow students to expand their own learning freely or it can give the instructors control over the direction they wish the students to research. Students gathering and comparing data from research prior to discussing a lesson can result in some very lively discussions (Vess, 1997). Vess (1997) gives an example of giving control to the students during research in an activity where students were asked to compare religions and languages in North Africa. This resulted in a lively discussion over the lasting impact of Islam in the middle ages (Vess, 1997). This activity gave students the freedom to take the research in whatever direction they chose. Because the student research leads the discussion, the process gives students more control over the direction of discussions and the information they learn.

An example of when the teacher takes more control of the research but still allow students to use critical thinking skills is demonstrated by was using scaffolds (Wolf & Brush, 2000). Scaffolds are tools, strategies, and guides which support students' ability to learn at a higher-level (Brush & Saye, 2001). Students were provided a database of links related to a topic. The study found the students gained a deeper understanding of the content when they were provided these links. Scaffolds are an example of how the teacher can control the initial student direction. After that the teacher-initiated control is implemented, it is up to the students to determine the direction of the research. The teacher may only supply the initial links and then the control is given to the students who determine the subsequent direction and the connections to be made from that point

forward. Student use little critical thinking when the teacher takes full control and gives students the actual links.

One of the biggest challenges facing technology instructors is the wide variety of backgrounds and prior knowledge students have in regards to technology (Murray, 1998). It is important to encourage individualized instruction. This can be accomplished through Internet-based research that allows students to make their own evaluation, analysis and connections based on their level of expertise within the area of study. Overall, the Internet is a great tool to facilitate critical thinking.

A study by Wolf & Brush (2000) found that using the World Wide Web as a source for information problem-solving resulted in a considerable change in students passing an American History test. Students were given a fifteen-question multiple-choice test prior to completing a research project that focused on the African-American Civil Rights Movement. They then were given the test at the conclusion of the project. The students using scaffolds scored significantly higher than the non-scaffold students (Wolf & Brush, 2000). This study is an example of how having students actively engage in information gathering can result in improved performance.

Barriers in Technology Integration

Databases, spreadsheets, concept mapping software, and Internet browsers are great tools for enhancing critical thinking. In order for technology to be integrated and used effectively by teachers to enhance learning they need to be properly trained to use the technology. . The next section of this review will investigate the impact teacher training has had on technology integration and what direction it needs to move in order to reach the goal of using technology as part of the process of critical thinking.

The most critical barrier for teachers to overcome in technology integration is the lack of sufficient training. Research has found the inability of teachers to use software is due to the lack of support teachers receive through training programs (Meyer, Steuck, Miller, Pesthy, & Redmon, 1999). Becker (as cited in Meyer et al., 1999) used a survey to determine schools with limited to no training programs used computers ineffectively. The study determined that there is a direct correlation between training teachers and teachers' ability to use technology in more complex ways then simple production projects. A report released by the National Council of Accreditation in September 1997 stated teachers need to develop a new approach to teaching, one that is designed for more active learning (Leh, 2002). The idea of teachers changing their approach to teaching to become more facilitators than information providers directly relates to integrating technology to encourage critical thinking.

Barnard (1997) compared two models for technology training programs and found that both models were strong in equipping teachers with an abundance of technology knowledge, but both models were very weak in the area of enabling teachers to use technology in ways that facilitated critical thinking. The research referenced indicates that student-centered activities such as scaffolds promotes the use of critical thinking skills and increases student performance (Brush & Saye, 2001). Teacher training is only one of the major barriers educators must overcome in order to start using technology in support of students developing critical thinking skills.

Some additional barriers for educators include lack of administrative and financial support given to teachers by school districts. The lack of administrative support, technology support, and parental support can create some major barriers for teachers to

overcome when using technology as mindtools (Jonassen, 2000). Research described a teacher who was committed to teaching technology to encourage critical thinking as part of a world history course in a high school in Alabama (Rice, Wilson, & Bagley, 2001). The Alabama teacher's goal was to make the content in the textbook more interesting and to get the students to increase their critical thinking skills when studying their history textbooks. The teacher assigned students sections in the textbook and they were required to do Internet-related research. The students were to integrate this research into multimedia presentations to present to their classmates. During this process, the students used critical thinking skills to create higher-level questions based on their research. The study determined that the students' class grade point averages improved by four percentage points. Even with this statistical evidence proving the students' performance was improving, and the failure rate has decreased from 22% to 5% the teacher was forced limit using technology (Rice, Wilson, & Bagley (2001). Although the teacher was penalized for using innovative ways to teach, he continued to use technology in the classroom. Over time, the teacher was asked by the principal to only use technology only for research purposes. As the teacher discovered, even if improvement is shown that is not a guarantee the teacher will have support from administration. This is huge barrier that must be overcome before educators can successfully integrate technology to encourage critical thinking.

An example of what could happen when a teacher and school receive financial and administrative support occurred in Boston, MA. The governor of Massachusetts announced a new education program that included innovative learning as an initiative to teach design and technology as academic subjects (Strufft, 2002). This program was

designed to enhance critical thinking skills by offering software and free teacher training

to every school in the state. Massachusetts' schools also received generous support with

gifts of millions of dollars in software grants. This type of commitment gives teachers

the freedom to get trained and to be empowered to create a curriculum that integrates

technology in a way where critical thinking skills are being used by students as part of the

every day school curriculum. Boston is an example of how providing financial support

and free training to teachers can overcome some of the barriers that exist in technology

integration.

Conclusion

This review of literature has examined several issues associated with integrating

technology to facilitate critical thinking. The number one obstacle for educators to

overcome is the lack of training in the areas of technology integration. This paper

provided an example of what can happen if there is a lack of administrative and

community support for technology integration. The Strufft (2002) example demonstrated

that the more support teachers get the more likely technology is going to be used as a tool

to encourage critical thinking. It is important that educators address the barriers early on

during integration process because it will make the transition from the traditional way of

teaching easier.

It has been the goal of this review to describe how technology can be used as a

tool to encourage and even enhance critical thinking skills. The key areas covered

throughout this review were defining critical thinking; identifying ways technology can

be used to facilitate or encourage students to use critical thinking skills, and studying the

barriers teachers must overcome in order to successfully integrate technology in their classroom.

Jonassen (2000) and Gordon (2000) agreed that critical thinking includes the process of evaluating and analyzing information so it makes sense to the learner. Jonassen (2000) adds the idea of making connections to evaluating and analyzing information. The idea of making connections to previous knowledge is a key fundamental aspect to long-term retention. Making meaning also relates directly to the idea of organizing and analyzing data using applications such as databases, spreadsheets, and concept maps. Both sources agreed that critical thinking has very complex definitions. Understanding the complexity of critical thinking is crucial and educators need to realize the difficulty of integrating technology to facilitate critical thinking.

The literature has provided examples of educators who have successfully used databases, spreadsheets, concept maps, and Internet databases as tools to enhance their students' critical thinking skills. The literature provided describes how these applications or pieces of technology can be used to support critical thinking. This review has provided an example of databases being used to research the Civil Rights movement and how spreadsheets can be used to assist students in making numerical connections to accelerate the mathematical development associated with those arithmetic concepts. It is equally crucial that technology continues to be integrated in such a way that students are learning more than just how to use the equipment and learn more about the process of using the equipment and learn more about the process of using equipment to assist them in the learning process. As Kalny (1999) stated, technology is changing so rapidly

schools can not keep up so educators need to make sure to teach students how to use technology regardless of the form.

Integrating technology as tools used to facilitate critical thinking breaks away from traditional teaching strategies and forces teachers to give control of learning to the students. Based on the literature, student-centered learning motivates students to learn and statistically students have performed better on assessments (Rice, Wilson, & Bagley, 2001). The idea of integrating technology in this manner is going to take time and teachers, administrators, and the public are going to need to be educated on this approach to teaching. Many innovators and reformers have realized that there will be several barriers standing in their way throughout the integration process. Historically, educators and the education system have been very reluctant to change. One example of what happens when a teacher loses support for technology integration was the teacher in Alabama who worked hard to integrate technology, yet the administration forced the teacher to quit using technology in spite of student improvement. On the other hand, Boston teachers are receiving free training and software to use to encourage their students to use technology to support critical thinking.

This review has established that integrating technology to encourage critical thinking supports improved students performance on various projects. There are three barriers innovators must be aware of and deal with; the lack of teacher training, lack of administrative support, and the lack of financial support. Educators have been so conditioned to use technology for production; it is going to take training and a change in their approach to teaching to get to a level where technology can be used as a tool to encourage critical thinking. Integrating technology as "mindtools" will provide students

the knowledge and ability to use critical thinking skills. The result of students using technology and developing critical thinking skills has caused some students to score higher on various projects.

Overall, this review has shown ways technology can be used to encourage critical thinking. Studies have shown that the more critical thinking students participate in the higher their performance in assessment measurements. This review has shown that technology can be used as a tool to encourage and even enhance critical thinking. The critical thinking skills students acquire give them the opportunity for improved performances. This is the direction education needs to move. Educators need to start using technology for more than production. Educators need to use technology in ways where it facilitates critical thinking by their students.

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