Discovery Learning for the 21st Century: What is it and how does it compare to traditional learning in effectiveness in the 21st Century?

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Introduction

The call is out! Schools must change. Businesses are becoming more interested in employees with the ability to solve problems. Leadership books, such as *Who Moved My Cheese?* (Johnson & Blanchard, 1998), are encouraging leaders in major companies, such as Exxon, General Motors, and Xerox, to look for employees who can easily adapt to change and "sniff out" trends. There is a call from businesses for employees who can look at what they are doing in their jobs and find ways to make it better and more competitive (McCain, 2000). Increasing global economic competition spurs businesses to look for higher achieving employees who need little training once hired (Lunenberg, 1998). Businesses look for 21st century employees and struggle to find them (November, 2000). Our society now expects graduates from school who are able to collaborate, work in teams, teach others and negotiate (Rice & Wilson, 1999). Businesses and society expect graduates to acquire, interpret, and evaluate data to learn, reason, and solve problems (Rice & Wilson, 1999). These skills are not typically found in graduates from the educational system today.

Traditional teaching and learning methods do not seem to be able to create the employee businesses look for today. It may be that there are other approaches to learning that would have greater success. Discovery learning seems to be a promising approach for a number of reasons. Discovery learning is an approach to learning that can be facilitated by particular teaching methods and guided learning strategies. For the purpose of this paper, the term discovery learning will refer to the learning taking place within the individual, the teaching and instructional strategies designed by the teacher, and the environment created when such strategies are used. Traditional learning will refer to the use of teaching and instructional strategies typically found in a teacher-led classroom, including didactic, drill and practice, and expository learning. The purpose of this review is to show that the availability of new technology calls for new research to consider the effectiveness of technology-based discovery learning as compared to the use of technology through a traditional approach. WebQuests, an Internet-based tool created by Bernie Dodge (1995), incorporates the principles of discovery learning into a usable classroom product. WebQuests create contextual learning that still addresses the required objectives in the test-driven educational environment found in today's schools. To demonstrate the need for comparative research that factors technology into both discovery learning and traditional educational approaches, a literature review of discovery learning and WebQuests was conducted. However, an exhaustive review would be nearly impossible considering the extensive writings on these topics. The scope of this review includes literature that defines discovery learning, outlines the theoretical and historical basis for discovery learning, describes practice and applications, and describes WebQuests as a current technologically-based application of discovery learning. This review includes the following topics:

- A definition of discovery learning
- The theory base of discovery learning
- An explanation of the architectures included in discovery learning
- The advantages and disadvantages of using discovery learning
- Technology's impact on discovery learning
- WebQuests as a viable first step to bridge the gap between the benefits of discovery learning and the existing circumstances found in schools, such as course content, preparation time, and class sizes
- Conclusions and Implications of the findings

What is Discovery Learning?

Discovery learning encompasses an instructional model and strategies that focus on active, hands-on learning opportunities for students (Dewey, 1916/1997; Piaget, 1954, 1973). Bicknell-Holmes and Hoffman (2000) describe the three main attributes of discovery learning as 1) exploring and problem solving to create, integrate, and generalize knowledge, 2) student driven, interest-based activities in which the student determines the sequence and frequency, and 3) activities to encourage integration of new knowledge into the learner's existing knowledge base.

The first attribute of discovery learning is a very important one. Through exploring and problem solving, students take on an active role to create, integrate, and generalize knowledge. Instead of engaging in passively accepting information through lecture or drill and practice, students establish broader applications for skills through activities that encourage risk-taking, problem solving, and an exa mination of unique experiences (Bicknell-Holmes & Hoffman, 2000). In this attribute, students rather than the teacher drive the learning. Expression of this attribute of discovery learning essentially changes the roles of students and teachers and is a radical change difficult for many teachers to accept (Hooks, 1994).

A second attribute of discovery learning is that it encourages students to learn at their own pace (Bicknell-Holmes & Hoffman, 2000). Through discovery learning, some degree of flexibility in sequencing and frequency with learning activities can be achieved. Learning is not a static progression of lessons and activities. This attribute contributes greatly to student motivation and ownership of their learning.

A third major attribute of discovery learning is that it is based on the principle of using existing knowledge as a basis to build new knowledge (Bicknell-Holmes & Hoffman, 2000). Scenarios with which the students are familiar allow the students to build on their existing knowledge by extending what they already know to invent new ideas. A good example of this attribute would be Papert's (2000) discussion of a kindergarten student's encounter with the LOGO computer programming language. She played with the program's speed setting and discovering the true meaning of zero. The student discovered that objects that were "standing still" were still "moving" just at a speed of zero. Through the student's playing with something with which she was familiar, she was able to create a new understanding of the concept of number including zero.

How do these three attributes combine to make discovery learning different from traditional forms of learning? The most fundamental differences are 1) learning is active rather than passive (Mosca & Howard, 1997), 2) learning is process-oriented rather than content-oriented, 3) failure is important, 4) feedback is necessary (Bonwell, 1998), and 5) understanding is deeper (Papert, 2000).

First, in discovery learning, students are active. Learning is not defined as simply absorbing what is being said or read, but actively seeking new knowledge. Students are engaged in hands-on activities that are real problems needing solutions. The students have a purpose for finding answers and learning more (Mosca & Howard, 1997).

Secondly, the focus shifts from the end product, learning content, to the process, how the content is learned. The focus in discovery learning is learning how to analyze and interpret information to understand what is being learned rather than just giving the correct answer from rote memorization. Process-oriented learning can be applied to many different topics instead of producing one correct answer to match one question that is typically found in content-oriented learning. Discovery learning pushes students to a deeper level of understanding. The emphasis is placed on a mastery and application of overarching skills (Bonwell, 1998).

Thirdly, failure in discovery learning is seen as a positive circumstance (Bonwell, 1998). Discovery learning emphasizes the popular lesson learned from Thomas Edison. Thomas Edison is said to have tried 1,200 designs for light bulbs before finding one that worked (Love, 1996). When someone asked Edison if he felt discouraged by so many failures, he responded that he never felt discouraged because he had learned thousands of designs that do not work. Learning occurs even through failure. Discovery learning does not stress getting the right answer. Cognitive psychologists have shown that failure is central to learning (Schank & Cleary, 1994). The focus is learning and just as much learning can be done through failure as success. In fact, if a student does not fail while learning, the student probably has not learned something new (Schank & Cleary, 1994).

Fourthly, an essential part of discovery learning is the opportunity for feedback in the learning process (Bonwell, 1998). Student learning is enhanced, deepened, and made more permanent by discussion of the topic with other learners (Schank & Cleary, 1994). Without the opportunity for feedback, learning is left incomplete. Instead of students learning in isolation, as is typical in the traditional classroom where silence is expected, students are encouraged to discuss their ideas to deepen their understanding.

Lastly, incorporating all of these differences, discovery learning provides for deeper learning opportunities. Learners internalize concepts when they go through a natural progression to understand them (Papert, 2000). Discovery learning is a natural part of human beings (Percy, 1954). People are born with curiosities and needs that

drive them to learn (Percy, 1954). Infants learn to talk by discovery. They listen to others around them talk, mimic sounds, and try putting together the pieces of language they have discovered (Percy, 1954). The infant develops a deep understanding of language by figuring it out one piece at a time. In an essay by Walker Percy (1954) entitled "The Loss of the Creature", Percy contrasts a young Falkland Islander with a high-school student as they both dissect a dead dogfish. The Falkland Islander stumbles upon the dead fish on the beach, pulls out a pocketknife, and dissects the fish. The high-school student is given a canned lesson containing an assignment, a list of every item needed, and the steps required to complete the assignment. The difference between the two examples is curiosity. The high-school student's gain of understanding is blocked by the circumstances in which the knowledge is being presented. The restrictions of school often dampen the natural curiosity that is innate in human beings (Percy, 1954). Discovery learning allows for deeper understanding by encouraging natural investigation through active, process-oriented methods of teaching (Percy, 1954).

Summary of Discovery Learning

Discovery learning is not like traditional classroom learning. It consists of three main attributes (Bicknell-Holmes & Hoffman, 2000):

- Through exploration and problem solving students create, integrate, and generalize knowledge
- Student driven, interest-based activities which the student determines the sequence and frequency
- Activities to encourage integration of new knowledge into the learner's existing knowledge base

The five major differences between discovery learning and traditional learning are (Bonwell, 1998; Mosca & Howard 1997; Papert, 2000):

- Learning is active rather than passive
- Learning is process-based rather than fact-based
- Failure is important
- Feedback is necessary
- Understanding is deeper

Discovery learning can be facilitated through various strategies, or architectures, in the classroom.

Theory Base of Discovery Learning

John Dewey (1916/1997), Jean Piaget (1954, 1973), and Lev Vygotsky (Rice & Wilson, 1999) all developed theories that serve as the foundation to discovery learning. All of these theories describe learning as active, process-based, and collaborative.

John Dewey

In *Democracy and Education*, Dewey (1916/1997) describes learning as action where knowledge and ideas emerge as learners interact with other learners in a community and build their knowledge by applying conclusions from past experiences that had meaning and importance. Dewey believed that children were naturally motivated to actively learn and that education only served to make more learning possible (Berding, 2000). He believed that mental development was achieved through social interaction. Dewey saw children as participants in their learning rather than receivers of their learning. To illustrate his theory, Dewey established a Laboratory School at the University of Chicago where students were encouraged to participate in active, group learning activities such as students' building a playhouse to learn geometry and measurement principles. Dewey believed that children should be active, participatory learners who collaborated with others to better understand meaningful situations.

Jean Piaget

In *To Understand is to Invent* (1973), Piaget wrote that understanding comes from discovery and that without understanding production and creativity are lost and the individual is caught in only repetition. Piaget theorized that children do not think with the same logic as adults (Papert, 2001). Piaget was the first to show that children were not "empty vessels" to be filled with knowledge, but active builders of knowledge. Piaget saw children as constantly creating and testing their understanding of the world, in other words, active, participatory learners. Piaget did not strive for educational reform like Dewey, but his theory about children's understanding has permeated education.

Lev Vygotsky

Lev Vygotsky emphasized the impact of cultural and social influences on cognitive development, particularly the interaction of children with other people in cognitive development (Rice & Wilson, 1999). Vygotsky introduced the theoretical concept of the zone of proximal development. In this concept, Vygotsky theorized that there is a difference in what a child can accomplish in isolation and what he or she can accomplish with assistance. In other words, a child is capable of solving more complex problems than would be possible at a particular mental age if the child has peers, teachers, and parents to assist in building the needed experiences. A good example of this theory is a kindergarten child who has been taken to a great deal of different cultural experiences that were discussed by a parent. The child will have a larger vocabulary, be able to relate to much more of the new content presented in the classroom, and be more eager to learn (Rice & Wilson, 1999). This child may appear very bright for a five-year-old, but have an average IQ. The difference is that the child has had an above average amount of experiences on which to base new information. Vygotsky felt that determining where a student was in his or her development and building the child's experiences so that richer discoveries could be made could enhance instruction in the classroom.

What are the Architectures of Discovery learning?

Dr. Roger Schank and Chip Cleary (1994) have proposed five main architectures for categorizing the architectures for discovery learning. The five architectures are 1) case-based learning, 2) incidental learning, 3) learning by exploring/conversing, 4) learning by reflection, and 5) simulation-based learning. By utilizing these architectures, teachers can build activities to allow their students to discover the desired concepts.

Case-based learning

The first architecture is case-based learning. Case-based learning has been in use for a long time. Harvard business school was one of the early adopters of the case-based method of teaching (Merseth, 1991). Business, law, and medical schools were some of the first groups of educators to adopt case-based learning. Schools of education investigated case-based learning in the early 1900s when business, law and medical schools were adopting it, but because of the expense of replicating the cases for study, education schools were unable to adopt the method (Merseth, 1991). Teacher education programs are now beginning to adopt the method (Baker, 2000).

Essentially, case-based learning is done through the use of stories or vignettes (cases) that contain the information or circumstances the teacher wants the students to learn. Students must examine the cases and base their attempts to make decisions on their knowledge of the content area (Schank & Cleary, 1994). Case-based learning takes advantage of "teachable moments" as students discuss how they are making decisions about the cases.

Incidental Learning

Incidental learning is probably the most entertaining form of discovery learning. In incidental learning, students gain knowledge "in passing" (Schank & Cleary, 1994; Bicknell-Holmes & Hoffman, 2000). Learning is a by-product of an incidental learning task in which the students are engaged. My experience has been that students typically love participating in incidental learning because many times the task takes the form of a game. Incidental learning activities work well with dull topics and rote memorization because they provide motivation to learn topics or skills that are typically perceived by students as not very interesting but are in the curriculum. Two examples of incidental learning would be to have a classroom game show or to make a crossword puzzle on the desired topic.

Incidental learning, because of its game-like quality, can be motivational to students. Students often become interested in the topic of study and look for answers because they want to do the activity and must have the knowledge to do it. Many incidental activities are also suited to students being involved in the creation process; hence, additional discovery opportunities result.

Learning by exploring/conversing

Learning by exploring is also known as learning by conversing. This type of discovery learning is based on an organized collection of answers to questions individuals can ask about a particular topic or skill (Schank & Cleary, 1994). The learning by exploring method is much like the Socratic method of questioning, answering, and questioning more. Students are given a mystery to solve and they can only solve it by asking questions. In this architecture, curiosity is intended to serve as a dramatic motivational tool.

An example of the learning by exploring architecture is playing "What's in the bag?" (Bicknell-Holmes & Hoffman, 2000). In this game, a bag containing an item is placed where it is visible. The object in the bag should reflect the desired topic for learning, for example, an elephant when studying animals. The students then ask questions to figure out what is in the bag. The students' mesh their past experiences and learning and the answers

given to formulate new questions to solve the mystery of what is in the bag. For example, in the case of the elephant in the bag, students may begin by asking if the object is living. When they receive the response that it is living, the students then begin to think of all the things they know that are alive and how the next question can narrow down the field. This process allows the students to not only learn that an elephant is an animal, but also discover new ways that the information they know about animals can be categorized.

Learning by reflection

In learning by reflection, students learn to apply higher-level cognitive skills by using an interrogative approach and reflecting on what they know in comparison to the qualities they are examining (Schank & Cleary, 1994). Learning by reflection allows the student to learn to ask better questions (Bicknell-Holmes & Hoffman, 2000). By learning to ask better questions, the students learn to do more sophisticated analyses (Bicknell-Holmes & Hoffman, 2000).

A teacher who employs the learning by reflection architecture typically answers questions with more questions to model how to better ask questions so that answers can be found. An example of learning by reflection would be the dialogue found in Table 1.

Student: Why are these frog eggs in water when a frog lives on land?
Teacher: What other animals can you think of that lay eggs in the water?
Student: A fish lays eggs in the water.
Teacher: Does a fish live on land?
Student: No.
Teacher: Can you think of any other animals that lay eggs in the water?
Student: A dragonfly lays eggs in the water.
Teacher: Does a dragonfly live in the water?
Student: No., it lives on land.
Teacher: Can you think of a way to find out how dragonflies and frogs are the same?
Student: Can I go to the Media Center?

Table 1: Dialogue example of learning by reflection

As you can see in this dialogue, the teacher does not answer the student's question directly. Instead, the teacher leads the student through reflecting on what he or she already knows and then guides the student in finding the answer.

Students not familiar with discovery learning find learning by reflection exasperating until they become better at the skill of asking good questions (Schank & Cleary, 1994). Learning by reflection requires a great deal of patience on the part of the teacher also because the purpose of this architecture is to discover better lines of questioning and reflect on previous knowledge (Schank & Cleary, 1994). Teachers must watch as students struggle and follow errant lines of questioning when seeking an answer. The students must make the mistakes and learn from them in order for their ability to ask sophisticated questions to develop so that they might better reflect on topics.

Simulation-based learning

Simulation-based learning is essentially role-playing. Students are given an artificial environment that allows for the opportunity to develop and practice a complex set of skills or witness the application of abstract concepts (Bicknell-Holmes & Hoffman, 2000). The benefit of students learning in a simulation rather than a real-life situation is that time and or the natural environment can be manipulated to guide discovery (Bicknell-Holmes & Hoffman, 2000). Also, students do not have to worry about the impact of failing in a simulation. For example, in a simulation where students are learning about adaptations of animals, students can put an elephant on the top of a mountain and see what happens without having to worry about a real elephant being harmed by their mistake in thinking that is where elephants live. Simulations also allow for things to occur that would be impossible in real life. For example, students could plan a space mission and actually take the mission through a simulation, whereas, taking an actual space mission would be impossible.

Technology has played a major role in making simulations easier to incorporate into the classroom. Computers allow for variability in more components of the simulation environment by taking the burden of manually manipulating data. Through technology, simulations can be much more realistic and authentic than without the use of the technology. Technology has provided a great advantage in implementing this architecture (Bicknell-Holmes & Hoffman, 2000).

Summary of Architectures

Essentially there are five basic architectures found in discovery learning. See Table 2.

Architecture	Description	Example
Case-based Learning	▪ Very old ▪ Students examine cases and discuss how to solve problems.	Groups of students are given a case to read and examine. The class then discusses possible solutions to the problem described.
Incidental Learning	▪ Game-like activities ▪ Motivational	Jeopardy game Crossword puzzle
Learning by Exploring/Conversing	▪ Students asking questions ▪ Encourages thinking of multiple ways to categorize	What's in the bag? game
Learning by Reflection	▪ Learning to ask better questions ▪ Builds analysis skills	Teacher answers a student's questions with additional questions for the student to answer
Simulation-based Learning	▪ Experimenting in an artificial environment ▪ Allows for trials without fear of failing	Planning and taking a space mission

Table 2: Summary of discovery learning architectures

Advantages/Disadvantages of Discovery Learning versus Traditional Learning

There has not been a great deal of research done comparing the discovery learning method and traditional teaching. From research that does exist, there appear to be four main areas of focus. These areas are 1) motivation (Hardy, 1967), 2) retention (Alleman & Brophy, 1992; Nelson & Fayer, 1972; Peters, 1970), 3) achievement (Hardy, 1967; Mabie & Baker, 1996), and 4) transference (Chambers, 1971).

A significant advantage of the discovery learning method is its capacity to motivate students. Discovery learning allows learners to seek information that satisfies their natural curiosity. It provides the opportunity for students to explore their desires and consequently creates a more engaging learning environment. Simply put, discovery learning makes learning fun (Schank & Cleary, 1994). In a study conducted by D.W. Hardy (1967), the students learning the principles of archaeology and anthropology through the discovery method of an archaeological dig were better organizers of information, more active in the task of learning, and more highly motivated than those who were taught in a traditional, lecture method. It is easy to imagine that students find it a lot more fun to dig out artifacts from an archaeological dig and figure out that the children that lived near the school 2,000 years ago played with rocks that they used as marbles than it is to read the same fact in a textbook.

In terms of information retention, discovery learning appears to be at least similar to the level found when using traditional teaching methods and possibly increases information retention. Alleman and Brophy (1992) conducted research with college students by asking them to report memorable kindergarten through eighth grade social studies activities. More students recalled activities that involved opportunities for experiential learning and higher order applications, characteristics of discovery learning, than activities that involved repetitive, low level seatwork. Students remembered more of what they learned in discovery learning activities than traditional activities. An older study also looked at the level of information retention among kindergarteners over a shorter timeframe. Peters (1970) compared kindergarten students learning mathematics through a discovery learning method and a verbal didactic instructional method. The students taught using a discovery learning method had equal retention to those taught using a traditional method.

In agreement with Peters (1970), Nelson & Frayer (1972) looked at the retention of concepts in their study comparing a discovery learning method and an expository learning method. Nelson & Frayer studied 228 seventh

grade students learning four geometry concepts (quadrilateral, rhombus, trapezoid, and parallelogram) and found that the students scored equally on retention tests

Discovery learning increases student achievement when the students are learning skills rather than facts. In Hardy's (1967) archaeological study, the students who were taught with the discovery learning method showed a positive significant difference in achievement on pre- and post-tests measuring anthropological understandings over those students taught using the lecture method. Rachel Mabie and Matt Baker in 1996 also showed an increase in achievement with their study of students learning about nutrition. Mabie and Baker studied three groups of fifth and sixth grade students who were taught about food and fiber using three different methods. One group was taught over a 10-week period using garden projects. A second group was taught using short, in-class projects, and the third group was taught using traditional methods. Both the garden project and in-class project groups showed an improvement in pretest knowledge of 70-80% compared to an 11% increase in the group taught using traditional methods. Nelson and Frayer (1972) and Peters' (1970) studies contradict Hardy (1967) and Mabie and Baker (1996). The traditional methods were found to be significantly better for achievement; however, the content taught in the Nelson and Fayer and Peters studies measured fact-based information and did not provide for open-ended responses that are more consistent with the discovery learning method.

The fourth area of discovery learning versus traditional learning is transference. D. W. Chambers (1971) did a study that compared discovery learning with overlearning. Overlearning is a traditional method of drill and practice in which students practice a skill many times. Chambers found that students learning with the overlearning method were better at transferring what they had learned than those who learned the concept through discovery learning. This study is greatly flawed due to the topic the students were learning which was rote memorization of math facts. Again, the fact that discovery learning does not work well with rote memorization impacted this study greatly.

Recognizing motivation, information retention, and achievement as positive effects of discovery learning that are grounded in research, the question becomes, why do teachers and school systems hesitate to adopt discovery learning. Some reasons are based more on self-imposed misconceptions and attitudes than on discovery learning's creative and practical demands (Bicknell-Holmes & Hoffman, 2000). Some reasons are because of imposed accountability and the structure of the educational system. Three major reasons teachers do not teach using discovery learning are that they believe 1) discovery learning will not cover the course content, 2) discovery learning will require too much preparation and learning time, or 3) class sizes are too big or too small to permit the strategy's use (Bonwell, 1998).

Educators fear that discovery learning will not cover the course content. This belief may stem from the fact that discovery learning is a square peg that is being placed in a round hole. Current curricula for K-12 education do not outline broad concepts to be learned. Instead, curricula detail isolated facts that students should know by a certain age (Schank & Cleary, 1994). Also, the structure of grade levels hinders discovery learning's natural progression. Students are given 180 days to learn a certain amount of content. Teachers cannot offer the amount of time some students would require to discover the content the teachers are held accountable for teaching (Schank & Cleary, 1994). Discovery learning does not work well on the same timeframe or with such specific, fact-based, information.

A second reason for a lack of discovery learning strategies in education is the belief that discovery learning will require too much time for preparation and learning. Theoretically, it should require less time for preparation (Schank & Cleary, 1994). The idea in discovery learning is to teach processing skills so that the initial investment in preparation is high, but the exercises and activities can be used repeatedly with minor adjustments to address different content areas (Bonwell, 1998). The preparation done by the teacher in discovery learning is simply to guide students as they build the investigation skills and then allow their investigation of the topic. Since the skills are easily transferable, creating new lessons do not take a great deal of time.

Preparation time should be less, however, learning time will be greater because students must be given time to explore. In the Nelson and Frayer (1972) study, it was noted that the students learning through a discovery learning method spent more time studying the lessons than those in the expository group. With current school structures and curricula, many times it is impossible to allow the time needed for discovery learning. It was not stated in the Nelson and Frayer study, but past experiences with discovery learning could play a part in the additional time spent. The skills needed to be efficient learners in a discovery learning environment must be learned; therefore, students' first attempts at learning through discovery learning would be different from their later attempts in terms of time needed (Schank & Cleary, 1994).

A third barrier to discovery learning is that class sizes are too large or too small for discovery learning. When looking at Dewey (1916/1997), Piaget (1954), and Vygotsky (Rice & Wilson, 1999), class sizes are almost always too large to use discovery learning in the way described because of the importance of one-on-one interaction.

On the other hand, group interaction is also important so that the collective experiences of the group can assist in the creation of new knowledge; therefore, if class sizes are too small, the collective experiences are limited. The key to addressing this disadvantage is finding the architecture that best fits the circumstances (Bonwell, 1998).

Three major barriers exist, but research has found some advantages in the areas of motivation, retention, and achievement. More research in the comparison of the discovery learning method versus traditional teaching on process-based content would be very beneficial. However, current school structure, in terms of class sizes, curricula and grade levels, and accountability requirements, including standardized tests, hinder the use of the discovery learning method in the classroom.

How has technology impacted Discovery Learning?

Skills developed through a discovery learning process seem to be more in line with the changing economy of today than more traditional, non-contextual, lecture methods of teaching. Discovery learning's focus on learning within context and using experiences as a guide are more closely related to the needs of the 21st century's economy (Lunenberg 1998). Because of the impact of Moore's Law, which states that technology will double in performance every 18 to 24 months (Moore, 1965), new careers are being created with every new technological advance (November, 2000). For example, a career in website development did not exist ten years ago because there was no World Wide Web. Now, however, there are entire companies in business solely to design websites. Teachers are preparing their students to assume careers upon graduation that do not even exist today. Therefore, education must find ways to adapt teaching and learning so that students become more independent, active learners (McCain, 2000). Professional organizations have called for students engaging in more active forms of learning involving hands-on activities, working in groups, completing projects, being assessed using performance-based assessment, becoming self-reliant, and engaging in self-directed inquiry (Rice & Wilson, 1998). Discovery learning offers these qualities and the technology of today can aid in the integration of discovery learning into the classroom.

In a relatively short period of time, technology has impacted every aspect of society (Strommen & Lincoln 1992); however, schools have been slower to embrace technology and change to adapt to the new technological environment (Schank & Cleary, 1994). Technology, however, makes discovery learning easier. Computers and the Internet give children greater autonomy to explore ever-larger digital worlds (Papert, 2001). No longer must schools be closed communities with little contact with the outside world. More opportunities exist than ever before for students to learn through discovery. The issues that made discovery learning difficult in the past, such as accessing current information and increasing student experiences, have been overcome by technology and are becoming ever easier as new technologies arise. Students are capable of building a learning community with a much greater collective experience base from which to draw by using technologies such as e-mail (El-Hindi & Leu, 1998). The tools improved by the Internet make discovery learning much easier than it was in the not too distant past. Technology makes the use of discovery learning architecture types easier (See Table 3).

Architecture	Technology's Impact on Using Architecture
Case-based Learning	▪ More cases available to be used in class ▪ Cases can be used in an electronic form so that the cost of resources (i.e. printing, paper, etc.) is reduced. ▪ Students have access to more information to find solutions to the cases through the Internet
Incidental Learning	▪ Online tools, such as Puzzlemaker.com (2001), make the creation of puzzles and games easier ▪ Information on topics is easier to find through the Internet to build games and puzzles
Learning by Exploring/Conversing	▪ A larger group of students with whom to converse through e-mail ▪ The ability to ask experts questions through e-mail and video conferencing
Learning by Reflection	▪ Searching for information on the Internet encourages students to refine questioning abilities to find needed topics

Simulation-based Learning	▪ Computers able to run more sophisticated simulation to create more realistic results ▪ Internet allows for multiple students to participate in one simulation so that interaction with others within the simulation are possible

Table 3: Technology use with discovery learning architecture types

As evidenced by Table 3, technology addresses two of the disadvantages of discovery learning, the required preparation and learning time and too large or too small classes. The preparation and learning time is greatly decreased by the Internet providing instant information and tools to use to prepare lessons. Computers address the problem of classes being too large by providing more student autonomy so that the student can ask questions and find answers without as much assistance from the teacher. E-mail and video conferencing address the problem of classes being too small because several classes of students can work together to create a larger body of collective experiences from which to pull previous information.

Technology can be used to compensate for some of the main disadvantages previously associated with discovery learning and simplify its use in the classroom. Technology has provided a source of information that gives society the freedom to change from a fact-oriented approach to learner to a process-oriented approach. For example, ten years ago, entire teams worked to maintain customer accounts and know what was ordered. Today a salesman in the field can know instantaneously everything about a customer and see what was ordered minutes before arriving at the office. No longer must the salesman focus on the customer order information. Instead the salesman can focus on how to get the customer to order more. Technology makes getting information easier than it has been previously and also has the potential to work well with discovery learning methods making it easier to use and, more importantly, making it a more effective strategy for learning.

WebQuests as a Viable First Step

Because the Internet is available in almost all schools now and many schools have Internet connections in every classroom, the environment for discovery learning in education is improving. Information is no longer a problem, but merging the requirements of standardized testing, curriculum, and class sizes remain as challenges for discovery learning to be used in formalized education. WebQuests are a viable first step to begin closing this gap.

In 1995, Bernie Dodge, developed the framework and guidelines for developing WebQuests. A WebQuest is an inquiry-oriented activity that uses resources from the Internet to complete a task. A WebQuest has six critical components: Introduction, Task, Resources, Process, Guidance, and Conclusion. WebQuests address many of the good points found in the architectures of discovery learning (See Table 4).

Architecture	Aspects addressed by WebQuests
Case-based Learning	▪ WebQuests are built around cases, real or imaginary, so that learning is contextual.
Incidental Learning	▪ WebQuests can be built around high interest topics that incorporate the skills to be taught (ex. WebQuest - Students research a classical musician, a pop musician, a country musician and a rock musician and compare how their music varies in pitch, intensity, and quality. Curriculum objective – Students will discover that sound varies in pitch, intensity, and quality (Georgia Department of Education, 2001).
Learning by Exploring/Conversing	▪ WebQuests encourage students to work in groups and discuss what they know and what they find out to complete the desired task.
Learning by Reflection	▪ With WebQuests, teachers act as facilitators to guide students through the learning process.

	Students must find their own answers by asking better questions to find the answers they need.
Simulation-based Learning	▪ WebQuests allow teachers to create simulated scenarios so that the students can role-play and discover new information.

Table 4: WebQuests in relation to discovery learning architectures

As can be seen in Table 4, WebQuests pull the best from discovery learning while still addressing the circumstances found in schools today, such as accountability using standardized testing, fact-based curricula, limited computers, etc. WebQuests can work toward raising test scores by incorporating testing objectives, meeting curriculum objectives by guiding students to learn the content that is expected, and using computers to obtain information while at the same time encouraging group work so fewer computers are needed even with a large class. One of the benefits to developing WebQuests is that they are adaptable to any subject, therefore one idea can be used for several different topics (Dodge, 1995). WebQuests utilize web resources so that students are using current information, but with the structure of the WebQuest, the students are not overwhelmed and the activity is streamlined so that not as much time is required to find the information (Dodge, 1995, Baker, 2000).

WebQuests help to overcome some of the previously stated disadvantages of discovery learning. The curriculum content can be addressed within the framework of the WebQuest. The structure of WebQuests allows teachers to prepare the activity more quickly than many types of discovery learning. The structure also narrows the resources students are using so that the learning time is decreased. The disadvantage of class sizes being too large or too small is also addressed through the use of WebQuests. Large classes can be broken into smaller groups so that the teacher can interact with the students in a small group rather than whole class and the small groups can interact with one another to share their learning. Small classes can be paired with other classes even if the classes are located in different schools. Because the WebQuest and the resources are available from any computer with an Internet connection, students can work together to complete the WebQuest assignment via the Internet and e-mail.

WebQuests seem like a solution to some of the earlier difficulties associated with using the discovery learning method in the classroom. WebQuests have been used, but there is a major gap in empirical data that compare the use of WebQuests to traditional teaching. There has been an influx of Webquests on the Internet with a lot of talk about them, but not a comparable amount of research done on their effectiveness.

Summary, Conclusions, and Implications

Discovery or constructivist learning is an active learning process where students develop higher-level skills to build a deep understanding of major concepts. There are five main architectures included in discovery learning, case-based learning, incidental learning, learning by exploring/conversing, learning by reflection, and simulation-based learning. All of these architectures are based on the theories described by John Dewey (1916/1997), Jean Piaget (1954), and Lev Vygotsky (Rice & Wilson, 1998). The 21st century is now presenting a more accepting atmosphere toward the discovery learning idea as businesses begin seeking employees who are better at figuring out situations and working independently. Technology has played a major role in this occurrence, but the structures of formal education in terms of emphasizing test scores, developing content-based curricula, and sizing of classes, still create a gap that makes discovery learning more difficult to integrate into the classroom. The framework developed by Bernie Dodge (1995), called WebQuests, appears to be a viable option to bridge the gap between the current demands of formal education and discovery learning.

From this information, it can be concluded that discovery learning matches what businesses and society want, however, current legislation, which leans toward accountability based on test scores, standardizing content-based curriculum, and maintaining higher class sizes to reduce cost work against discovery learning being adopted into the classroom. Also, the shortage of professionally trained teachers in the market hinders discovery learning's adoption. Teachers must be trained on and understand completely the pedagogy and theories of working with young children in order to effectively embrace discovery learning. The current 21st century environment is ripe for discovery learning to take hold because of the increased capabilities of technology, the demands of an international economy, the shift in the stability of jobs in the workplace, and the increase in the number of careers people will have over a lifetime. Society is also showing signs of wanting something different. Home-schooling and private school enrollment is at an all time high. Parents are enrolling their children in innumerable outside activities to give

them experiences in dance, art, gymnastics, foreign language, etc. The information in this review shows that not just a reform of education needs to occur, but a revolution. But, how does one start a revolution?

RESEARCH! Without research, all the talk is just rhetoric. Through using concepts such as WebQuests, which tap into the good qualities of discovery learning while still working within the current educational system, research that compares discovery learning with traditional, didactic, drill and practice, and expository teaching in the K-12 environment needs to be done. It needs to be decided whether or not discovery learning is a viable answer to making students better prepared for the adult world they will one day enter.

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