Discovery Learning in the Classroom

1 author:

Emily Brown
Sheridan College

Discovery Learning in the Classroom

Emily Sandford Brown
March 2006

Tell me and I will forget
Show me and I may remember
Involve me and I will
understand.
Confucius, 450 B.C.

What is discovery learning?

Why has Discovery Learning come to the fore (what impediments to learning might have brought this on)?

How is discovery learning linked to other educational theories?

Is Discovery learning a stand alone method of instruction and if not, what other teaching methods work best in conjunction with discovery learning?

What does discovery learning look like in the classroom?

Are any special skills or knowledge needed for a teacher to use the discovery learning method in the classroom?

What are the advantages and disadvantages of discovery learning as a pedagogical style, especially in the elementary science classroom, according to current research?

Does discovery learning affect a deeper learning experience than other more traditional teaching methods?

How does discovery learning accommodate students with learning exceptionalities and the different learning styles of boys and girls?

Could discovery learning which is seen as more collaborative rather than competitive help reduce bullying?

What we have to learn to do, we learn by doing. - Aristotle

Introduction

From the time a child is born until he reaches school, the way he learns about his world is through discovery. If discovering a child's environment provides him with such a vast amount of knowledge prior to going to school, why do we not continue to use discovery methods *at* school, especially in science instruction?

"Children are naturally curious and inquisitive, and love to explore their environment. It is normal to want to know how things work and why the world is the way it is. At its most basic level, this is what science is all about. The most important question in education, then, is this: what tools are children given to understand the world."[1]

In the times of Socrates (known for his Socratic method of inquiry in the building of knowledge and understanding) and Aristotle (who set the stage for what would centuries later be described as the scientific method), students were encouraged to ask questions, experience and discover in order to learn and gain deeper meaning. It was only in more recent times, with the establishment of an institutionalized schooling system that a different, more industrial form of educational pedagogy was developed. This pedagogy called the transmission theory viewed students as clean slates or empty vessels which the teachers would simply fill with prescribed knowledge. But as the pendulum swings back and forth, different methods of teaching gain support. A pedagogy which

[1] www.skeptic.com, Science and Skepticism.

resonates with the philosophies of the past has emerged and has gained credibility. It is called ‘Discovery Learning’.

What is Discovery Learning?

Discovery Learning is an active, hands-on style of learning where the student participates actively in the learning process rather than passively receiving knowledge as if he were an empty vessel to be filled by the instructor. It is an approach to instruction through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments and is supported by the theories of learning and understanding from cognitive psychology and constructivist ideologies. Students are encouraged to think, ask questions, hypothesize, speculate, cooperate and collaborate with others and develop confidence in problem solving and in using what is in their own minds.

Why would Discovery Learning come to the attention of educators in schools and teacher preparation programs now, especially for consideration in the science classroom? What are the main impediments to learning that teachers face in schools that Discovery Learning might address?

The most insipid problem facing schools today is the apathy or lack of motivation in students. At some point in a student’s education the fire that is their natural curiosity is doused by a curriculum or mode of teaching that is not keeping their interest. A student certainly in the upper grades can often be heard saying, ‘just tell me what you want me to know for the test and I will learn it’ with no interest in the subject or what is really out there to learn. John Dewey wrote extensively about the connection between interest and effort in education back in the early 1900’s and what he said still rings true today. He said that things taught at school should not be 'made interesting', but rather they should already be 'of interest' to the students, thereby keeping apathy at bay and he noted that there is a clear connection between interest, activity and satisfaction in learning. David Suzuki reiterated Dewey's concerns specifically about science instruction more recently by saying,

"That natural capacity to be excited when discovering things in the world around us is so precious and so easily extinguished that I think political posturing about getting Canada into world-class science is a waste of time unless we devise ways to keep our most talented youngsters interested." [2]

This apathy can be attributed in part to a lack of connectedness to the real world of either today's curriculum or in how that curriculum is addressed. If science in particular is presented as some long ago list of facts or something that does not affect the lives of students, then apathy is sure to bring a pall over the classroom. Concern for effective science instruction however is not new, as again, we read statements made by John Dewey in Science magazine in 1910 where he notes that,

"Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject-matter."

Fast forward one hundred years and a modern, 'knowledge age' society exists which is more in need of people who have a keen interest in science and the ability to inquire and problem solve as issues such as climate change, feeding an ever growing population and preventing pandemics, as disease after disease

[2] Suzuki, David. Inventing the Future. (1990)
Allen & Unwin , NSW, Australia pg 193

threatens the globe need to be tackled. In Alberta, the shortage of people trained in science and technology has reached crisis levels.

"The most important issues that the next generation will have to contend with will result from the application of science and technology. An interest in these fields needs to be encouraged. Unfortunately, for many youngsters today, the way science is taught in school turns them off, and too many have stopped taking any science course midway through high school. It doesn't have to be that way."[3]

David Suzuki argues that the way science is being taught in our schools is a major attributor to students opting out of the science classroom and ultimately out of our industries, and research laboratories.

"Right now, science is being taught on a totally unrealistic model and unfortunately, for the majority of our students, it's a turnoff very early. Indeed, the word science is pretty much of a pejorative by the time they reach high school-it's a subject for the "math brains." And certainly for most teenagers, science is an activity so esoteric that it really isn't relevant to their daily lives."[4]

Science instruction often takes on this rote, transmission style in the classroom because of the lack of trained, qualified, interested, motivated teachers, whose fear of or disinterest in science has them quoting what needs to be learned in the science curriculum from outdated textbooks. In the elementary grades in Alberta schools for example, a teacher need only have to have a prior degree for admission into a teaching faculty and it is common not to have a background specifically in science or math. It is only in secondary school science instruction where those teaching science need a prerequisite science degree. We do not have more science trained teachers because those individuals who take on science and math in post secondary institutions are often drawn to professions other than teaching.

3 Suzuki, David. Inventing the Future. (1990). Allen & Unwin , NSW, Australia pg 190

4 Suzuki, David. Inventing the Future. (1990). Allen & Unwin , NSW, Australia pg 193

“The vast majority of teachers who teach the pitiful amount of science in primary schools is very poorly grounded in science, having had perhaps a few hours of lectures in the education faculty a decade or more previously. It’s certainly not the teachers’ fault, but these days when we hear so much about the information explosion and the need to get in on the action in high technology it’s tragic that so many children are uninterested in science by the time they reach more highly qualified teacher in high school” [5]

In science classrooms therefore the battle is on to conquer apathy, lack of connectedness to the real world and poorly prepared teachers. Discovery Learning is credited by some with bringing science instruction to new heights, or should I say depths, of inquiry, exploration, problem solving, and higher level critical thinking skills, but how does Discovery Learning manifest itself?

What does Discovery Learning look like in the classroom?

Perhaps this question is best approached by first looking at what it does not look like in the classroom. According to scientist/geneticist David Suzuki,

“When I was a high school student, we went into the lab and were told what the experiment would be, received a set of instructions and then were expected to use the equipment to obtain data. Because the emphasis was on the mechanics of doing experiments, we frequently lost sight of the reason for doing them. Without an appreciation of the body of knowledge, insights and theories that make an experiment definitive, a student can go through a lab exercise like a cook following a recipe. In high school, the part of the lab exercise most prized by teachers seemed to be the ‘write-up’. We were drilled in the proper steps: define the purpose, describe the materials and experiential methodology, document the results, discuss the implications and finally draw conclusions. Not only did we have to conform to this protocol, but our reports were often graded on whether we obtained the ‘right answer’. Having been a scientist now for more than twenty-five years, I can tell you that this is *not* how science is done, and we lose a great deal by teaching it this way.”[6]

---

5 Suzuki, David. Inventing the Future. (1990). Allen & Unwin , NSW, Australia pg 193

6 Suzuki, David. Inventing the Future. (1990). Allen & Unwin , NSW, Australia pg 191

This type of ‘pre-packaged’ science work has even percolated down to the elementary grades. If ‘pre-packaged’ science is wrong in high school, it is certainly wrong in the elementary classroom where a child’s natural curiosity and desire to explore is the greatest gift to learning. But in a classroom focusing on Discovery Learning, that curiosity and desire to explore is harnessed.

In today’s classrooms, Discovery learning and the new technologies go hand in hand. Where real life exploration is not possible modern technology can provide ‘virtual environments’ for students to explore, for example ancient sites such as Stonehenge or the Pyramids of Egypt, or the palace of Versailles during the French Revolution. The many live webcams can allow students to experience a forest fire, volcanic action, or the hatching of bald eagle chicks in a nest anywhere in the world. Simulation programs can be used for frog dissections in the biology class (Operation Frog) or for studying the development of communities (Sim City). With these simulations students can still be challenged, change parameters, study the results of those changes, evaluate, assess, process, and make other changes on their path to building knowledge and gaining understanding. As technology is used more often in hands-on classrooms, it has fueled a demand for good educational software. Lego Mindstorms ™ is an example of a system consisting of computerized robotics developed originally for educational purposes to provide hands-on learning opportunities in math, science and computer and design technology.

“Many teachers find simulations offer effective supplements to real labs, either to prepare students for making good use of actual labs, or as a follow-up with variations on the original experiment.”[7]

[7] Conway, Judith. Educational Technology’s Effect on Models of Instruction (1997)

Project work done in small collaborative groups but with a large group focus is often a part of the Discovery Learning classroom and is conducted for the most part using class time. Group work allows for the skills and knowledge gained in the small group work to be reinforced and each student's discovery will lead to another's discovery but all reinforce the learning of the other. By contrast, individual project work in a Discovery Learning environment is less desirable as much of the learning by the individual is for the individual only.

"A well planned relevant class project has extremely high motivation and is a dynamic tool for discovery. A class project, creatively presented, can help students conceptualize many aspects of what they have studied in class. Their discovery is well worth your time. "[8]

In a Discovery learning classroom, there is a lot of discussion, either in small working groups or together as part of a whole class dialogue. Although noise levels may be higher, it is evident that the level of engagement is higher too and off task behaviours and the need for active 'classroom management' is minimized. This discussion or dialogue revolves around the ideas of the students, not just factual material but viewpoints, hypotheses, and clarification of concepts. Because Discovery Learning often sees students work in groups, the respect that develops is evident in these discussions where others' comments are heard with an open mind and without criticism.

If students are to engage in discovery and inquiry in the classroom, they will need access to information and equipment in order to investigate and test their

---

http://copland.udel.edu/~jconway/EDST666.htm

[8] Mamchak, P. Susan and Mamchak, Steven R. Handbook of Discovery Techniques in Elementary School Teaching. (1977) pg 158

ideas. A Discovery Learning classroom needs to be full of resources, and more of them, including access to books, videos, magazines, computers, even experts in the field. It was evident that real Discovery Learning was being taken up at the special Science school where students had ongoing communication with the Canadian Space agency, the Zoo and other ‘expert’ resources.

Is Discovery Learning a stand alone method of instruction and if not, what other teaching methods work best in conjunction with Discovery Learning?

As discussed earlier in this paper, Discovery Learning in the classroom has so many advantages for a very diverse group of students, but if left on its own, Discovery Learning has had a tendency to diminish into just a series of activities, giving students little opportunity to construct knowledge, ask questions and go on to further discoveries. It is important then to incorporate other methodologies into the classroom to increase the effectiveness of Discovery Learning. In the article entitled The Science Storm which discusses the controversy between direct transmission instruction and Discovery Learning, a balance in methodologies was encouraged and in fact it was noted that the two ‘camps’ are not so far apart on the spectrum as one might think.

David Klahr who has done extensive research on metacognition in students, and particularly with regards to science knowledge with his ‘control variable experiments’ has found that the best science instruction can be described as a

‘spectrum of methods that stretch from nothing but lecture and instruction on one end to nothing but hands-on at the other. The best instruction happens somewhere on that spectrum, not necessarily at one end or the other ‘what is needed is what is effective’. A good science teacher behaves like a good scientist, by using what works in a particular situation, not by relying on a single method for every situation."[9]

It is important to note that Klahr, when conducting his research, considered only the two extremes of science pedagogy, 'stand and deliver' instruction on the one hand and completely unguided, unsupported discovery on the other, in order to make his point. His most recent studies were conducted in June of 2005 and he is planning further research in this area.

Is Discovery Learning supported by any particular psychological theories?

Discovery Learning is firmly supported by psychologists linked to cognitive learning and constructivist theories where knowledge, according to educational psychologists such as Kant, Piaget, Vygotsky and Bruner and educational philosopher Dewey, is something that you have to do; learning is a matter of 'knowing' and 'doing'. They found behavioural theories unacceptable with regards to the teaching of children and proposed that children actively construct knowledge and this construction of knowledge takes place in a social context. A learner's prior knowledge affects his subsequent learning. Piaget, for example, viewed children as little philosophers and scientists building their own individual theories of knowledge.

> **"**Piaget's research clearly mandates that the learning environment should be rich in physical experiences. Involvement, he states, is the key to intellectual development, and for the elementary school child this includes direct physical manipulation of objects" [10]

---

[9] Crane, Elizabeth. The Science Storm. www.districtadministration.com

[10] Haury, David L. and Rillero, P. Perspectives of Hands-On Science Teaching (1994). North Central Regional Educational Laboratory http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

There is an emphasis on students' ability to solve real-life practical problems.

Bruner stressed learning by doing.

> "The school boy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else" (Bruner, 1960). Bruner states, "Of only one thing I am convinced. I have never seen anybody improve in the art and technique of inquiry by any means other than engaging in inquiry" Bruner points out the quick rate of change in our world and says, "the principal emphasis in education should be placed on skills - skills in handling, in seeing, and imaging, and in symbolic operations" (Bruner, 1983) "[11]

Discovery learning and inquiry based learning have been linked and often the terms are used interchangeably. In the past a distinction has been made between inquiry and discovery with the former assigning a more active role to teachers as organizers and shapers of students' learning, and the latter giving more power to students to take the process of discovery wherever it leads[12] although I see this distinction graying in my experience.

What are the necessary teacher skills required for Discovery Learning to be successful?

Hands-on Discovery Learning, although it yields greater benefits in the classroom, requires a great deal of preparation time, flexibility and organization. It is not an easy task. A teacher must ensure that what is discovered is educationally valuable and that further investigations are supported and encouraged.

[11] Haury, David L. and Rillero, P. Perspectives of Hands-On Science Teaching (1994). North Central Regional Educational Laboratory http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

[12] Osborne, Ken. Teaching for Democratic Citizenship (1991). Our Schools/Our Selves Education Foundation, Toronto, Canada. pg 28

Very young children arrive at school with a very natural interest in their world and the need to find clarity, correctness and adequacy in what they already know, and in some cases to challenge what they know. Teachers play a crucial role here in the Discovery Learning classroom by finding ways to encourage this drive for knowledge. The teacher must help the children again and again to ask the kinds of questions about their understanding and beliefs in all areas of life in order to provide these young students experiences to discover and test these understandings.

Teachers need to be ready to see and accept their changing role, one which moves the teacher from one who knows everything and passes that on to the students to one who facilitates learning.

"The job of the teacher in constructivist models (such as in a Discovery Learning environment) is to arrange for required resources and act as a guide to students while they set their own goals and 'teach themselves'."[13]

This does not mean that a teacher needs to know less or be of less influence, rather it means quite the opposite. Teachers allowing students to discover in class need to be more well rounded, and knowledgeable information gatherers in order to be able to guide a student from an idea or question he may have to a deep and meaningful learning path. Teachers therefore must be much more willing to take on a greater responsibility for Professional Development. One teacher's experience at a school where deep and engaging Discovery Learning was taking place found that Professional Development became more meaningful

[13] Conway, Judith. Educational Technology's Effect on Models of Instruction (1997). http://copland.udel.edu/~jconway/EDST666.htm

“as we grew to trust ourselves as learners and to see challenges as opportunities to make a difference, we become role models for what we expect from our students” [14]

Early on in this paper the point was made that many science teachers especially in the elementary grades do no have much background in science and that this can be a serious impediment to students’ learning. For science instruction, even at the elementary level, a teacher needs to have a solid grounding in science, either by being well-schooled, well read or by being otherwise engaged in their own personal development. Collaboration with colleagues who have a strength or interest in science is a great way to engage in inquiry.

If we consider a classroom where Discovery Learning techniques are being used a constructivist classroom, then the following information about requisite teacher knowledge is very relevant.

“Research within the last several years has indicated the importance of deep and strong subject matter knowledge in a constructivist classroom, be it K-12, teacher education, or professional development. This requires knowledge of the structure of a discipline as well as its epistemological framework. Such knowledge helps teachers in the interpretation of how students are understanding the material, in developing activities that support students in exploring concepts, hypotheses and beliefs, in guiding a discussion toward a shared understanding, providing guidance on sources for additional formal knowledge, and, at times, correcting misconceptions.

The depth of subject matter knowledge necessary to provide these experiences for students may be found in secondary teachers who major in a particular content, are teaching that content, and, by and large, see themselves as teachers of that content. However, we have to question what the expectations concerning subject matter knowledge suggests for teachers at the elementary school level. Since the constructivist research is being carried on within individual subject matter--mathematics, science, history, or language arts--there seems to

---

[14] Green, Anne. Let Them Show Us the Way. (1995) Fostering Independent Learning in the Elementary Classroom. Peguis Publishers. Winnipeg, Manitoba, Canada

be little or no acknowledgment that other subject matters are also being taught. We are quite clear that constructivist teaching requires a deep understanding of the disciplines, of the ways in which students learn the content, and of the teaching practices specific to that discipline on the part of the teacher. However, is it a reasonable expectation, and if so, how will it be possible to insure that elementary teachers have the requisite level of knowledge in all the disciplines they are expected to teach?"[15]

One curriculum supervisor in a major American school district writes,

"School districts need to spend more time getting science teachers connected to current research. Professional development needs to be taken seriously. The same way that a pilot needs to learn about a new plane that he is going to fly, science teachers need to know about the latest methods."[16]

and the same applies to science teachers in Canada.

The executive director of the National Science Teachers Association entered the debate about whether direct instruction or discovery learning provides the best learning and with regards to teachers he said that science teaching methods lie on a spectrum,

"from completely explanatory [direct transmission] to completely exploratory [unguided discovery]. A good teacher has a bag of tricks and can pull out the appropriate trick based on the topic and the age of the student. A combination of interaction and explanation are needed for the student to be able to grasp the concept being taught, and the teacher learns where on the spectrum a particular age group falls. A good teacher knows when to give instruction, knows when to walk away."[17]

In the book Handbook of Discovery Techniques, there was a story recounted about a teacher who brought an anatomical human model which came apart into her grade three classroom. One day the class arrived in the morning to find the model entirely taken apart with instructions from the teacher to work together as a group and put the model back together. Without any help from the teacher, the

---

[15] Richardson, Virginia. Constructivist Pedagogy. (Dec 2003). Teachers College Record 105 no9 1623-40

[16] Crane, Elizabeth. The Science Storm. www.districtadministration.com

[17] Crane, Elizabeth. The Science Storm. www.districtadministration.com

students got to work and made some great discoveries, such as the heart is behind the lungs and the kidneys are at the back. They put the model together the first time without knowing all the names of the parts but the exercise was very rich nonetheless. By the end of this unit, the students were putting the model together using the correct names of all the parts. What was noted in the book is that,

“the apparatus involved is not that important. What does matter is the teacher’s approach to the subject. It might have been constructing a phylum tree, making an airplane, or modeling a volcano. The teacher allowed her students to discover, and then she led them, step by step, to a natural conclusion based on their own discoveries. “[18]

Teachers using Discovery Learning techniques realize that often the best learning will take place outside of the classroom and often, to keep the real world connections that are so valuable, outside in the community with other keen and knowledgeable adults. A good collaborative spirit and a willingness to partner with other knowledgeable adults is important for teachers in a Discovery Learning environment. One article I read was about Calgary schools taking their classes to learning sites in and around Calgary such as City Hall School and comments on the value of these field trips to constructing knowledge and understanding through discovery.

“Teaching that combines the skills of teachers and the specialized knowledge of adults outside school leads to deep understanding as students connect to the rich resources their community has to offer.”[19]

[18] Mamchak, P. Susan and Mamchak, Steven R. Handbook of Discovery Techniques in Elementary School Teaching. (1977) pg 127

[19] Cochrane, Cathy. Landscapes for Learning. (S 2004) Educational Leadership 62 no 1 78-81

A question arises about how a teacher will assess what a student has learned in a classroom where Discovery Learning is taking place and does a teacher need any particular skills in assessing. Often testing is a way that teachers assess learning and knowledge but is the ‘end’ in this learning process really the important part and not the ‘means’. It is suggested in such a classroom that a good teacher will know at any given moment where a student is in his learning. They see what the child is doing, get feedback by asking good questions of the student, read the students’ faces and can react immediately to a student’s work or progress to set them right on the path to solving his own problems. It is not necessary or desirable to wait to the end and determine what a student has not learned by making them take a test.

This method of assessment is more in line with formative assessment as it takes into account that there are many paths to the same end and what is of most importance is that the path is right for that individual student and it is working for them. Although this is important for all students, this individual path and formative assessment technique finds the greatest value for children with learning exceptionalities.

In summary,

“Teachers become a poser of questions, a provider of hints, a provider of materials, a laboratory participant, a class chairman and secretary. He/ she gathers the class together and solicits data gathered and their meaning. Most importantly, the teacher is not a teller. He/ she is a facilitator and director of learning. If materials are well chosen, good questions are posed, timely ideas are suggested, and students are prompted to think through questions, alternatives, answers, and data, then much can be done to encourage the acquisition of more adaptive mental structures."[20]

Advantages of Discovery Learning

- Students who have difficulty in learning for reasons of ESL barriers, auditory deficiencies, or behavioral interference can be found to be on task more often because they are *part of* the learning process and not just spectators.

"As classrooms become more inclusive, prospective and practicing teachers need to apply strategies that assure the full participation of students with disabilities. As elementary classrooms are becoming more diverse ethnically and developmentally, "Science for All" must become a reality in classrooms throughout the country." [21]

Science is one subject where it is believed that equal learning opportunities can be provided regardless of whether the student has ESL concerns, has learning or behavioural detriments or performs poorly academically.

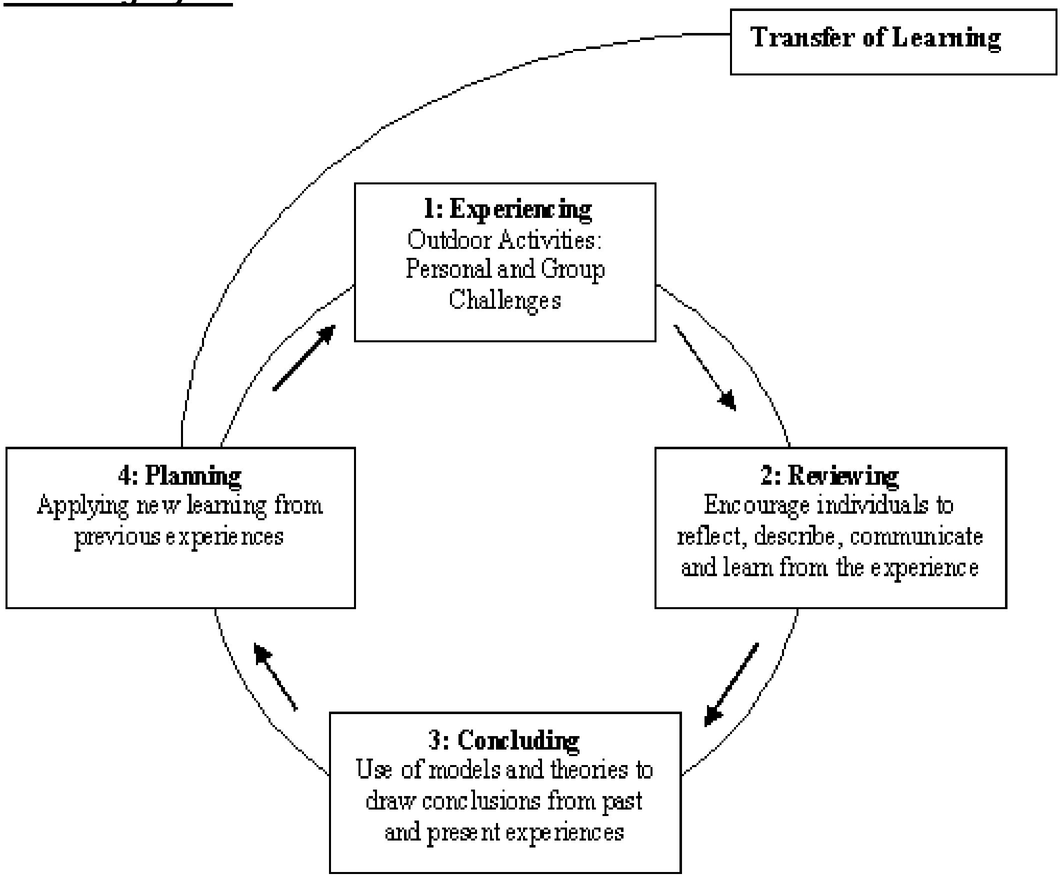
"General education teachers identified science as the subject area most amenable for mainstreaming students of all disability categories; and special education teachers identified science as a subject that is particularly useful for many students with disabilities. Science is preferred when it uses constructivist approaches such as the Learning Cycle, which combines exploration, convergent instruction, and divergent reasoning into a guided discovery strategy. Such an approach offers many opportunities for differentiating instruction and accommodating learner needs. Activities-based, guided discovery approaches promote thinking, and foster problem solving abilities. These approaches also offer multi-sensory learning experiences, which are supported by research on the brain and cognition." [22]

[20] Lawson, Anton E. *Neurological Basis of Learning, Development and Discovery: Implications for Science and Mathematics Instruction.* Secaucus, NJ, USA: Kluwer Academic Publishers, 2003. p.24.

[21] Sounds and Sense-Abilities: Science For All. College Student Journal 38 no4 653-60 D 2004

[22] Sounds and Sense-Abilities: Science For All. College Student Journal 38 no4 653-60 D 2004

Learning Cycle



As we consider how Discovery Learning addresses the impediments to learning discussed earlier in this paper, it was noted in the article about teaching students with disabilities, especially in inclusive classrooms that,

"The elementary and middle school years are cited as the time when budding scientists are "won" or "lost." The challenges of engagement and retention are at least doubled when students are impaired in some way.[23]

As teachers we have a limited time to grab students and interest them in science and the challenge seems even greater with students with learning disabilities.

[23] Sounds and Sense-Abilities: Science For All. College Student Journal 38 no4 653-60 D 2004

- Discovery Learning allows for each child despite their individual strengths and challenges to have an experience, of their own making which will deepen their knowledge and understanding of any topic, but especially in math and science.
- Students will remember the material better and feel a sense of accomplishment when the task is completed.
- Students who have learned through Discovery Learning will be able to transfer that experience easier to other learning situations. When more than one method of learning is accessed as in hands-on learning, the information has a better chance of being stored in the memory for useful retrieval.
- The benefits of Discovery Learning are noteworthy in those children who are either not as academically "talented" or have not shown "interest" in school. This method tends to stimulate these types of students into participating and eventually absorbing information that they might not get from "normal" *show-me - tell-me*, transmission methods.
- Discovery Learning makes teaching fun, and if the kids are learning and having fun doing it, then teachers are also enjoying their work more.
- Without discovery learning, students must rely on memory and abstract thought, two methods which restrict learning in most students. John Dewey writes that ‘abstractness is the worst evil that infests education’. By actually doing and experiencing science, students develop their critical thinking skills as well as discover scientific concepts. This self discovery stays with students throughout their lifetimes while memory fades.

The widely controversial book A Nation at Risk published in 1983 called attention to the serious problems of schooling in America and some changes were recommended to help set education on the right course.

"In order to succeed in the twenty first century schools must graduate students who are prepared to be lifelong learners. This challenge necessitates a pedagogical shift from transmitting a body of expected knowledge that is largely memorized to one that is largely process oriented." [24]

- Discovery Learning encourages student creativity in problem solving, and promotes student independence or the 'heuristics of discovery', finding out things independently.
- Discovery learning can be more motivating, incorporating the pleasures of solving puzzles and controlling an environment.
- Hands-on Discovery Learning in science has been shown to help in the development of language and reading.

Researchers have concluded from their study that science activities can make a positive contribution to the acquisition of reading skills and oral communication skills of all students but specifically of first grade students. These activities can provide the concrete experiences from which many reading skills are derived. In my third semester practicum experience I observed this phenomenon first hand. For many of my grade one students, writing in their journals was a struggle. Concerned with proper spelling and grammar, they were reluctant to just write. It was only when I was able to have my students engaged

[24] Conway, Judith. Educational Technology's Effect on Models of Instruction (1997) http://copland.udel.edu/~jconway/EDST666.htm

in some wonderful magical hands-on discovery science related to colour and rainbows did their writing blossom. Being real scientists in the class and writing about what they used, what they did, and what they saw gave them purpose to their writing and their discussions with me and with their classmates.

“Rather than responding to teacher-assigned topics, they [students] become keen to share stories related to their personal experiences…Students cannot write from thin air; meaningful experiences are crucial for expressive writing to emerge. Especially in today’s world of passive television viewing and look-alike shopping malls, children need interesting hands-on experiences to think and write about.”[25]

- Discovery learning facilitated by a knowledgeable regular classroom teacher who learns along with the students, helps to reinforce the idea that science is for everyone and not just for scientists. Also learning, when it involves other knowledgeable people in the community, for example the previously mentioned City Hall School, allows students to see science in many different environments which may spark an interest in a career that might otherwise not be explored.
- Discovery Learning, because it is so engaging, is more effective in creating students who are life-long learners, something that is seen as very important in the twenty first century.

“Educators have realized that for students to be successful in the twenty first century they need to be lifelong learners. Helping them to develop the skills necessary to become lifelong learners requires a different approach to teaching and learning. The direct instruction method that was used almost exclusively in the earlier part of this century, though still effective for some skills, is giving way to a more cooperative approach. One that involves the students working together toward common goals, teachers serving as ‘experts’, and coaches, and

[25] Cochrane, Cathy. Landscapes for Learning. (S 2004) Educational Leadership 62 no 1 78-81

facilitators, and sometimes just plain getting out of the way and letting students discover things for themselves."[26]

- Discovery learning is based on the assumption that education is a process, not a set of facts and as is suggested by Scardamalia and Bereiter, students engaged in this kind of learning are better prepared to engage in 'knowledge building'
- Discovery Learning improves students' attitudes toward science and there is even some evidence from exemplary programs that even poorly taught hands-on Discovery science is more interesting to students than the typical textbook based program
- Discovery Learning, because of its knowledge building environment, minimizes what is referred to as the 'Matthew effect', which notes that the rich get richer and the more you know the more you can learn. The 'Matthew effect' suggests that there is a widening gap between haves and have-nots even in education which we already see in the widening income gap, but that Discovery Learning which allows students to build authentic knowledge, which is connected to their world, their community and their lives, may ensure that 'continual advancement remain open for all.' [27] This is not to say that absolute equity in education is possible but Discovery Learning is certainly a step in the right direction for many disadvantaged students.

[26] Conway, Judith. Educational Technology's Effect on Models of Instruction (1997) http://copland.udel.edu/~jconway/EDST666.htm

[27] Scardamalia M and Bereiter, C. Knowledge Building. (2002) Encyclopedia of Education, 2nd Edition. New York: Macmillan Reference, USA

- Active learning puts the responsibility on the student. When a student is placed in the position of having to figure out a problem, he is much more likely to take charge of his own learning. This leads to students moving from extrinsic to intrinsic rewards for success in learning.
- Students, being actively involved in their own learning, forces them to construct a response and this results in the deeper processing of information than can be attained with mere memorization; students learn how to learn.

- Discovery Learning provides students with an opportunity to get early feedback on their understanding: gaps in their understanding cannot be ignored. For students there is an ‘eventual’ attainment of concepts but the gradual approach means that the concepts are frequently reinforced and re-discovered. Indirect lessons (not unplanned as might be the criticism) are often self-directed and self-managed using the ideas that children have with the teacher asking many questions. Reaction to student’s answers lead to further questions which help to clarify information and leads to higher achievement of students.
- Discovery Learning activities result in "episodic memory," a deeper kind of memory specific to an event so that if a student cannot at first remember the idea or technique he can reconstruct it from the event.
- Discovery Learning better enables a student to deal with misconceptions and construct new knowledge based on this new experience.

“when dealing with misconceptions, direct learning sometimes has little or no effect in overcoming the misconception. When you directly tell the learner something that contradicts their misconception it has no impact. If you try to do a straight explanation when talking density to a fifth grader, odds are they won't get the concept. If you don't let them explore, they don't get it. But if you don't explain the concept and the formula then all their exploring may or may not lead to comprehension, especially when dealing with students below sixth grade."[28]

Discovery Learning as a teaching method seems undeniably beneficial and even more so the younger it begins. In this paper's introduction, it was observed that a child's first method of learning about their world is through discovery. As time goes on, if a child is denied that very natural, beneficial way of learning, a dependency on teachers or prescribed materials can develop.

"The importance of the early use of hands-on learning has been long recognized. The study of both plants and animals should begin in the lowest grades, or even in kindergarten. One object of such work is to train the children to get knowledge first hand. Experience shows that if these studies begin later in the course, after the habit of depending on authority - teachers and books - has been formed, the results are much less satisfactory"[29]

This phenomenon was observable in my grade 4 practicum class at the Calgary Science school where the intake began after students had been at other schools for the first four years of their formal education and where discovery, inquiry and problem-based learning may not have been prevalent. Students often struggled with being more responsible for their learning, with organizing their information, asking informed questions, and forming hypotheses and conclusions.

---

[28] Crane, Elizabeth. The Science Storm. www.districtadministration.com

[29] Hoary, David L. and Rillero, P. *Perspectives of Hands-On Science Teaching (1994).* North Central Regional Educational Laboratory http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

In the earliest years, discovery can take place with an oral account of what has been learned, moving onto written accounts once those skills have emerged with the *process* of discovery and inquiry being the focus. Discovery Learning and hands-on activities are critical for elementary school science learning, particularly because elementary students are at the concrete stage of their cognitive development.

Disadvantages of Discovery Learning

- The greatest pitfall of Discovery Learning is that if it is done poorly and without purpose and meaningful discussion, these methods used in the classroom can deteriorate to children simply being busy with ‘activities’. ‘Hands-on’ does not equate with ‘minds-on’.

Scardamalia and Bereiter, Canadian educational researchers draw a distinction between merely hands-on and real discovery with their use of the terms shallow and deep constructivism, with shallow constructivism denoting the ‘busy work’

“the shallowest forms engage students in tasks and activities in which ideas have no over presence but are entirely implicit. Students describe the activities they are engaged in (eg planting seeds, measuring shadows) and show little awareness of the underlying principles that these tasks are to convey.”

This type of activity driven busy work may have been what was underlying the investigation at the local charter school visited by our class where it became evident that the students were following directions to the letter and had failed to ask discovery questions which would allow them to better grasp the deeper scientific concepts.

After considering all the advantages and possible disadvantage of Discovery Learning, it is important to determine if there are any long term empirical studies to support Discovery Learning as a better way to instruct students in the classroom. Research data collected in more than fifty studies, conducted on 13,000 students in the United States in classrooms over a fifteen year period was gathered and the evidence in support of Discovery Learning was indisputable.

"Educational research has shown many advantages of using hands- on science programs. Bredderman (1982) reports the results of a meta-analysis of 15 years of research on activity-based science programs. This synthesis of research was based on approximately 57 studies involving 13, 000 students in 1, 000 classrooms. All of the studies involved comparing activity-based programs (the Elementary Science Study, Science-A Process Approach, or the Science Curriculum Improvement Study) with comparable classrooms using a traditional or textbook approach to science teaching. A variety of student performance measures were analyzed. The most dramatic differences were found in science process skills where the students in activity-based programs performed 20 percentile units higher than the comparison groups. The students in these programs scored higher than the control groups in the following measures (ranked from largest to smallest differences): creativity, attitude, perception, logic development, language development, science content, and mathematics. Students who were disadvantaged economically or academically gained the most from the activity- based programs."[30]

<u>Does Discovery Learning affect a cognitively deeper learning experience than more traditional teaching methods?</u>

Discovery Learning by its very nature should demand a higher level of cognitive skills development as a student is asked to manipulate, hypothesize, question and experiment in his world. Although it takes longer for children to form a generalization on their own than it does for them to learn

[30] Hoary, David L. and Rillero, P. *Perspectives of Hands-On Science Teaching (1994).* North Central Regional Educational Laboratory http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

one that is presented to them prescriptively, it is crucial for school children, especially in the elementary grades to learn by discovery where important attitudinal and higher level cognitive skills are attained. Higher level cognitive skills are knowledge, comprehension, application, analysis, synthesis and evaluation. These all form an integral part of learning by discovery in the classroom.

David Klahr on his own and with colleagues Junlei Li and Milena Nigram has conducted many extensive studies into neurological learning paths, the psychology of scientific thinking and cognitive research into how students learn in science labs and classrooms. In a recent study they questioned whether the way a child was taught a certain skill, concept or procedure once mastered would impact the transferability of that skill or whether that knowledge was somehow embedded more or less deeply into the child's brain. This brought into question the claim that discovery learning causes a deeper understanding. Klahr and his colleagues predicted that the way that a student reached mastery had no bearing on whether that knowledge was more transferable or available. Once learned, whether by direct instruction or discovery methods, the knowledge was the same. This is only a prediction and ongoing studies are taking place.

Conclusions

Over the past two years in the MT program, I have learned a great deal about teaching and learning. It seemed to me early on and is even more evident now that children learn best when given the opportunity to be active participants in their learning, to ask questions, form hypotheses, experiment, explore and discover. The guided Discovery Learning method provides the best opportunity for learners supported by other more traditional methods. With this information, it it is encouraging to see that its advantages are being noted and used to develop the new Alberta science curriculum.

“The new curriculum emphasizes hands-on learning. Students learn best when they become personally involved in their learning - when they are doing more than following a set of steps or just reading and hearing about things learned by others.
Students develop their skills of inquiry and problem solving. Students as scientists explore and investigate, look for patterns, and find out what is related to what. They learn by observing and handling things, communicating what they observe, and keeping records.
As problem solvers, students learn to apply scientific knowledge to practical uses. For example, in grade 4, students use wheels and axles to make simple machines that will move a load from one place to another.”[31]

In closing, a short quote from a recent study on the neurological basis of learning seems to encapsulate the benefits of Discovery Learning as

“a teaching approach that allows students to explore nature, to discover what they do not know, and to eventually make connections with what they do know (often using analogies), which makes learning more motivating, easier, better understood, longer lasting and more transferable.” [32]

---

[31] Alberta Government Education
http://www.education.gov.ab.ca/news/1996nr/august96/nr-science.asp

[32] Lawson, Anton E. Neurological Basis of Learning, Development and Discovery: Implications for Science and Mathematics Instruction. Secaucus, NJ, USA: Kluwer Academic Publishers, 2003. http://site.ebrary.com/lib/ucalgary/Doc?id=10067229&ppg=41

<u>Bibliography</u>

Bergstrom, Joan M. and O'Brien, Lisa A. *Themes of Discovery*. (Apr 2001) Educational Leadership 58 no 7 29-33

Cochrane, Cathy. *Landscapes for Learning*. (S 2004) Educational Leadership 62 no 1 78-81

Collins, Allan, Brown, John Seely and Holum, Ann. *Cognitive Apprenticeship: Making Thinking Visible*. (Winter 1991) American Educator, the Journal of The American Federation of Teachers.

Conway, Judith. *Educational Technology's Effect on Models of Instruction* (1997) http://copland.udel.edu/~jconway/EDST666.htm

Crane, Elizabeth. *The Science Storm*. District Administration, (March 2005) www.DistrictAdministration.com

Dewey, John. *Interest and Effort in Education* (1913, reprinted in 1970) August M. Kelly Publishers, New York, New York, USA

Egan, Keiran. *Imagination in Teaching and Learning: the Middle School Years*. (1992) Althouse Press, London, Ontario, Canada

Gardner, Howard. *The Unschooled Mind: How Children Think and How Schools Should Teach.* (1991). Basic Books New York, New York, USA

Green, Anne. *Let Them Show Us the Way: Fostering Independent Learning in the Elementary Classroom*.(1995) Peguis Publishers. Winnipeg, Manitoba, Canada

Haury, David L. and Rillero, P. *Perspectives of Hands-On Science Teaching* (1994). North Central Regional Educational Laboratory http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-2.htm

Harlen, Wynne. Primary *Science; Taking the Plunge: How to teach science more effectively for ages 5 to 12.* (2001). Heinemann, Portsmouth, New Hampshire, USA

Henton, Mary. <u>Adventure in the Classroom</u>. (1996). Project Adventure Inc. USA

Isaacs, Nathan. *Children's Ways of Knowing*. (1974).Teacher's College, Columbia University. USA

Klahr, David and Li, Junlei. *The Psychology of Scientific Thinking: Implications for Science Teaching and Learning*. (2006) Teaching Science in the 21st Century. National Science Teachers Association and National Science Educational Leadership Association. NSTA Press

Klahr, David and Li, Junlei. (June 2005). *Cognitive Research and Elementary Science Instruction: From the Laboratory, to the Classroom, and Back*. Journal of Science Education an Technology, Vol. 14, No. 2

Klahr, David and Nigram, Milena. *The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning*. (2004) Psychological Science.

Lawson, Anton E. *Neurological Basis of Learning, Development and Discovery: Implications for Science and Mathematics Instruction.*
Secaucus, NJ, USA: Kluwer Academic Publishers, 2003.
http://site.ebrary.com/lib/ucalgary/Doc?id=10067229&ppg=41

Mamchak, P. Susan and Mamchak, Steven R. *Handbook of Discovery Techniques in Elementary School Teaching*. (1977) Parker Publishing Company, Inc. West Nyack, New York, USA.

Morine, Harold and Morine, Greta. *Discovery: A Challenge to Teachers*. (1973) Prentice-Hall, Inc. Englewood Cliffs, New Jersey, USA

Osborne, Ken. *Teaching for a Democratic Citizenship*. (1991) Our Schools/Our Selves Education Foundation. Toronto, Ontario, Canada

Richardson, Virginia. *Constructivist Pedagogy* (2003).Teachers College Record 105 no9 1623-40

Saab, Nadira, van Jooligan, Wouter R. and van Hout-Wouters, Bernadette H.A.M. *Communication in collaborative discovery learning*. (2005) British Journal of Educational Psychology

Scardamalia M and Bereiter, C*. Knowledge Building*. (2002) Encyclopedia of Education, 2nd Edition. New York: Macmillan Reference, USA

Science and Skepticism
www.skeptic.com

Sounds and Sensibilities: Science for All. College Student (Dec 2004) Journal 38 no 4 653-660

Snowman, Jack and Biehler, Robert. *Psychology Applied to Teaching 10th edition* (2003). Houghton Mifflin Company, Boston, MA, USA

Suzuki, David, *Inventing the Future*. (1990)
Allen & Unwin , NSW, Australia

Ying-Tien Wu and Chin-Chung Tsai. *Effects of contructivist-oriented instruction on elementary school students' cognitive structures*. (Summer 2005) Journal of Biological Education 39 no 3 113-119

Victor, Edward and Kellough, Richard D. *Science K-8: An Integrated Approach*, (2004)10th edition, Pearson Prentice Hall, USA

Alberta Government Ministry of Education
http://www.education.gov.ab.ca/news/1996nr/august96/nr-science.asp